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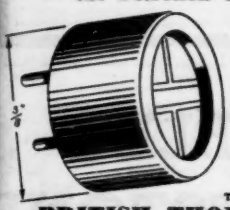

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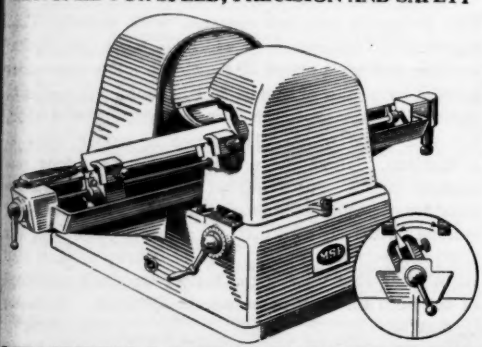

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NATURE

No. 4305 SATURDAY, MAY 3, 1952 Vol. 169

CONTENTS

	Page
National Research Development Corporation	719
Technical Ferromagnetism. By Prof. L. F. Bates, F.R.S.	721
Applied Mechanics for Engineers. By Prof. A. S. T. Thomson	722
Chemistry in War-time Germany. By Prof. H. W. Melville, F.R.S.	722
Freshwater Algæ. By Prof. Lily Newton	723
Clowder of Cats	723
The Greenshank. By Seton Gordon, C.B.E.	724
The British North Greenland Expedition, 1952–54. By R. A. Hamilton	727
Psychological and Physiological Aspects of Fatigue. By A. T. Welford	728
Developments and Science in the Soviet Union. By Dr. S. M. Manton (Mrs. J. P. Harding), F.R.S.	729
Obituaries:	
Prof. N. V. Sidgwick, C.B.E., F.R.S. By Prof. T. S. Moore	732
Sir Leonard Hill, F.R.S. By Dr. T. C. Angus	733
Dr. Thomas Wayland Vaughan. By Dr. H. Dighton Thomas	734
Dr. Leonard Dobbin. By Prof. James Kendall, F.R.S.	735
News and Views	735
Properties and Physiological Role of Asparagine and Glutamine, with a New Interpretation of the Structure of Asparagine. By Prof. F. C. Steward and Dr. John F. Thompson	739
Systematic Shifts in the Ultra-violet Absorption Spectra of Polycyclic Aromatic Hydrocarbons. By W. F. Maddams	743
Forest Products Research: Report for 1949	744
Carnegie Trust for the Universities of Scotland: Annual Report for 1950–51	745
Letters to the Editors:	
A Radio-Astronomical Investigation of Winds in the Upper Atmosphere.—A. Maxwell and C. G. Little	746
An Investigation, using Scintillation Counters, of 'Double Stars' due to Cosmic Rays.—J. B. Harding	747
A Simple Rotating-Cell Double-Beam Unit for Spectrometers.—J. D. S. Goulden and S. S. Randall	748
X-Ray Diffraction Pattern of Ammonium Fluoferrate.—H. M. Rice, Dr. R. C. Turner and J. E. Brydon	749
Environment and Respiratory Control in Certain Crustacea.—Dr. Barbara M. Walshe-Maetz	750
Nucleic Acids in Erythrocytic Stages of a Malaria Parasite.—P. R. Whitfield	751
Occurrence of Larval Helminths in *Gammarus pulex* (L.) from the Braid Burn, Edinburgh.—Dr. M. B. Lal	752
Stourophora mertensii Brandt in the Firth of Clyde.—D. T. Gauld	752
Inhibited Development of *Dictyocaulus* Larvæ in the Lungs of Cattle and Sheep.—Dr. E. L. Taylor and J. F. Michel	753
Fusarium Wilt of Guava (*Psidium guyava* L.) in Uttar Pradesh, India.—N. Prasad, P. R. Mehta and S. B. Lal	753
Occurrence of the Terrestrial Alga, *Fritschiella tuberosa*, Iyengar, in Africa.—Dr. A. J. Brook	754
Possible Protozoan Remains in Permian Salt.—M. W. Strong	754
Absolute Stereochemical Configuration of Morphine.—Dr. I. R. C. Bick	755
S-Methyl Dithizone and the Structure of Metal Dithizonates.—Dr. H. Irving and C. F. Bell	756
Organic Derivatives of Montmorillonite.—G. Brown, R. Greene-Kelly and K. Norrish	756
Irreversible Inactivation of the Cationic Groups of Collagen by High-Molecular Acids.—Dr. K. H. Gustavson	757
Formation of Amino-Acids in Hydrolysis of Adenine.—Dr. G. Frick	758
Use of Glass Fibre Material in Soil Mycology.—Betty J. Legge	759
Breeding Behaviour of the Emperor Penguin.—Bernard Stonehouse	760

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NATIONAL RESEARCH DEVELOPMENT CORPORATION

THE second annual report of the National Research Development Corporation*, which covers the year ended June 30, 1951, indicates that the Corporation is making steady progress in securing harmonious liaison and co-operation with the numerous sources of invention throughout Great Britain which are in receipt of public grants in some form or other. Such co-operation and liaison are essential if the Corporation is to make a substantial contribution to the exploitation of invention, or to take an assured place in the research structure of the country. It is unlikely that any sound judgment can be formed on the value of the Corporation for several years yet, and particularly as to the adequacy of its financial resources: the present report suggests that the five million pounds contemplated as expendable over its first five years work is unlikely to be required unless some quite unforeseeable need arises. Development expenditure is expected to be low in these early years and to increase as the number of inventions with which it is concerned accumulates, and as each individual invention sponsored approaches a degree of maturity where increasing certainty as to its prospects would justify heavier expenditure upon it. Moreover, some of the problems in which the Corporation can play a useful part in the general interest do not necessarily involve additional expenditure by the Corporation, or may even provide revenue; often the functions of the Corporation are purely introductory and advisory, and any expense in pursuing the matter, such as development expenditure, is borne by the industry concerned.

The Board of the Corporation is thus unable to give any budgetary forecast of expenditure; it is equally unable to forecast monetary returns on its investment in inventiveness, or to estimate how long a period must elapse before it can show a direct monetary profit and commence to write off its accumulated administrative expenditure out of such profits. Nevertheless, it takes the view that the Corporation's work represents a long-term investment in British inventiveness, and that other advantages will accrue nationally before monetary returns are visible in the Corporation's accounts. Meanwhile, the Corporation's work is being progressively and comprehensively linked up with that of the government departments, the Department of Scientific and Industrial Research, the Agricultural Research Council and the Medical Research Council stations and the universities and industrial research associations of the United Kingdom. Some of these lines of communication, in particular the relations with the universities, were described and discussed in some detail in the first report of the Corporation. An appendix to the present report details the directions given to the Corporation by the Board of Trade, dated June 28, 1951, regarding the exercise of the Corporation's functions in relation to patent rights

* National Research Development Corporation. Report and Statement of Accounts for the Year 1st July 1950 to 30th June 1951. Pp. 18. (London: H.M. Stationery Office, 1952.) 9d. net.

transferred by government departments, and also the views of the Treasury upon the transfer of government rights in inventions to the Corporation.

As a result, when a new device or process originates in one or other of these centres, the Corporation will obtain adequate notice of it at a date early enough to take the ancillary steps necessary to ensure its development or exploitation in the public interest. So far as government departments are concerned, the arrangement excludes secret inventions and also inventions relating primarily to defence purposes, atomic energy and gas turbines, inventions in respect of which licences have already been granted by departments, inventions the exploitation of which is likely to be confined principally to a department's own field and can best be exploited by that department, and inventions which can appropriately be exploited through the radio patents pools or which on ethical or other grounds are normally not exploited on a commercial basis but in respect of which non-exclusive licences are granted for a nominal fee. This has been achieved without embarrassing scientific workers by any restriction upon publication and, at the same time, the Board notes that scientific men are more aware of the need for avoiding prejudicing a nationally advantageous discovery by publication prior to making a patent application. The Board claims that in consequence it is increasingly in a position to ensure that inventions which might in themselves be regarded as trivial are fitted into a more embracing pattern of inventive subject-matter by collation of all the communications made to the Corporation in a given field.

This is a large claim, the justification of which must make considerable demands on the Board itself, which in September was strengthened by the addition of Mr. J. F. Lockwood, Sir Rowland Smith and Sir Henry Tizard, and on the Corporation's staff of forty-six (an increase of eight on the previous year). Of the Corporation's folio of 409 United Kingdom granted patents and 488 patent applications, 177 patents and 286 applications were from the Ministry of Supply, 142 patents and 100 patent applications from the Admiralty, 69 patents and 23 applications from the Department of Scientific and Industrial Research and one patent and 41 patent applications from the universities. The report points out that the progress of invention entails a high rate of wastage, which will in future years involve abandoning patent applications and granted patents; but no annual report could hope to display the soundness or otherwise with which such a portfolio is handled. Wisely, the Board has contented itself with selecting two projects for special mention.

The Corporation is keeping a very close watch on all developments in the field of electronic digital computors, in view of their potential industrial importance, as well as their use to mathematicians; and it is ensuring that patent cover is available to all creative inventors, and proposing a very substantial development programme. Some eighty inventions in this field are covered by British and foreign patent applications vested in the Corporation.

In view of the importance of potatoes in the national food supply, the Corporation has set up a development company, known as the Packman Harvester Developments, Ltd., with a panel of technical advisers nominated by the Ministry of Agriculture and the National Institute of Agricultural Engineering, to further the development of a combine potato harvester designed by Mr. P. J. Packman.

Besides this, in the absence of initiative from other sources, the Corporation assisted in arrangements for the collection and allocation of animal pituitary glands for the manufacture of the adrenocorticotropic hormone used for the treatment of rheumatoid arthritis and other diseases. After discussions with the Medical Research Council, the Ministries of Food and Health, the Association of British Chemical Manufacturers and the industrial firms primarily interested, a special Pituitary Gland Allocation Committee was established, the Corporation providing a chairman and secretarial services. This collaborative effort has very substantially increased gland collection from abattoirs, and the Ministry of Health is placing contracts for supplies of the hormones which, for the time being, will be allocated to the Medical Research Council for experimental clinical research work.

In the scientific instruments field, the Corporation has also taken the initiative by arranging with the British Scientific Instrument Research Association and the Scientific Instrument Manufacturers Association to study individual proposals for instruments, so that their value can be assessed and recommendations made for their development and exploitation. In this way it is hoped to remove difficulties which potential users, including medical research laboratories, sometimes experience in obtaining certain types of specialized equipment from British instrument makers and to improve the availability of facilities for prototype design, manufacture and testing, prior to reduction to the production stage. The Board does not interpret the Corporation's functions as normally including the provision of working capital for private inventors; but it endeavours to put such inventors in touch with likely *entrepreneurs* or possible users if any are known to it. The Corporation's responsibility to the private inventor is interpreted rather as being along the lines of paying for the development work necessary to give practical embodiment to immature but fertile ideas of a sufficient public importance. In the Board's opinion, this can be best achieved by demonstrating a fully engineered prototype to "a firm engaged in the industry concerned" and thereby proving that the invention is a sound one.

The Corporation thus appears to be filling a useful place in the nation's research structure, and its operations are being directed sensibly and in ways calculated to secure the co-operation and inspire the confidence that are essential for it to discharge the responsibilities laid upon it by the Development of Inventions Act, 1948. The analysis of inventions communicated during 1950–51 in comparison with the figures for the previous year suggests both that such co-operation is being secured, and that the

functions of the Corporation are becoming more clearly understood. Of the 1,317 inventions communicated in the year ended June 30, 1951, 752 were from government departments, 81 from universities, 13 from industrial research associations and 442 from private sources, as against 444, 20, none and 485, respectively, out of 965 in the previous year.

No one would suggest that the National Research Development Corporation is more than one factor in the development of a national policy for research; but, within its limits, its first two annual reports suggest that the Corporation may come to make important contributions, at least in redressing the balance of research and development effort and assisting to shorten the period between discovery and practical application.

TECHNICAL FERROMAGNETISM

Ferromagnetism

By Richard M. Bozorth. (Bell Telephone Laboratories Series.) Pp. xvii+968. (New York: D. Van Nostrand Co., Inc.; London: Macmillan and Co., Ltd., 1951.) 130*s*. net.

IT is an extraordinary feature of the books which have been published on magnetism during the past twenty-five years or so that they overlap so very little; the two books which were recently published within a few weeks of one another, one American and one British, exhibit this somewhat desirable feature. R. M. Bozorth's "Ferromagnetism" really breaks new ground, for it is essentially a book written for the technician and the industrial metallurgist or physicist. This statement is not meant to imply that academic research workers will not find the book interesting or stimulating. Indeed, it would be hard for anyone not to be interested in the wonderful array of diagrams and pictures which the author places before us. I merely wish to indicate that in its pages one must not look for deep academic discourses on special aspects of the subject—although many of us know that the author has contributed much fundamental new knowledge to our store—but rather that the busy works-technician will here find a kind of encyclopædia of ferromagnetic phenomena which he can consult rapidly without fear of error. If the same busy technician wishes to improve his mind in his free time, then he will also find an enormous and well-arranged set of references the reading of which will occupy him for some years to come.

It has already been mentioned that the book contains a wealth of illustrations. Let us briefly survey the contents. The first two chapters, on the concepts of ferromagnetism and the composition, production and outstanding properties of magnetic materials, contain fifty illustrations or slightly more than one a page. The next three chapters, dealing with the manufacture and properties of commercial-quality and pure iron, the iron–silicon, iron–nickel, iron–nickel–molybdenum, iron–nickel–chromium, iron–nickel–copper, iron–cobalt–nickel and other iron–nickel alloys, extend over some 145 pages and contain 158 illustrations. The two following chapters, on iron–cobalt alloys and certain iron alloys of high permeability, form some seventy pages with sixty-eight illustrations; incidentally, the latter chapter contains a short but interesting article on ferrites.

Under a chapter on other high-permeability materials, one finds descriptions of the metallurgy and properties of cobalt, cobalt–nickel and other alloys, Heusler and manganese alloys, and finally some references to materials like silver fluoride and gadolinium—more than ninety pages with eighty-four illustrations. The next chapter on permanent magnets, some eighty pages with sixty-four diagrams, gives a very wide survey of the whole subject, although one or two references to British work on these magnets appear to be missing; but, here again, the busy works-technician will find very much important information ready to hand.

The book then proceeds to the more theoretical aspects of magnetism, and once more the treatment is designed to meet the needs of the technician rather than those of the academic student of the subject. Some fifty pages with thirty-one diagrams are devoted to the theories of ferromagnetism, diamagnetism, paramagnetism and antiferromagnetism. A wealth of detail is then given concerning the magnetization curve, and its interpretation on modern domain theory, in a chapter of fifty-two pages with seventy-two illustrations.

In some forty pages and thirty-six pictures are covered the magnetic properties of crystals, including, of course, rotational hysteresis. Perhaps the most extensive chapter is that on stress and magneto-striction, with its fifty pages and 144 diagrams, wherein the domain theory is invoked in the most simple and direct manner to give the technical expert a sound idea of the present state of our knowledge. Curie-point phenomena are discussed in relatively few pages – some fourteen with fourteen diagrams. Energy of magnetization, specific heat and magneto-caloric phenomena are also described—sixteen pages and fifteen pictures.

The relatively short chapter on the relations between the electrical and the magnetic properties of materials is, as one would expect from such a well-known worker in the Bell Telephone Laboratories, extremely good; again, twenty-seven more diagrams. Magnetic time effects, including eddy-current effects in sheets, etc., are studied and illustrated with thirty-one diagrams. Special problems in domain theory, such as the properties of domain walls and of fine particles, are well treated, although the author must obviously have exerted great self-restraint in order to confine within less than forty pages with seventeen illustrations the description of so many important experiments in which he himself has played a leading part. The measurements of magnetic quantities are rather briefly reviewed (seventeen more illustrations) and various useful data are given in appendixes, followed by a very extensive bibliography of some seventy-nine pages.

Perhaps the insistence in this review on the wealth of diagrams and numbers of pages in the several chapters may strike the reader as rather unusual and possibly boring; but this is a very expensive book, and it is essential that prospective purchasers should have a shrewd idea of its range and contents. I have never thought it possible to have 'magnetism without tears'; but this book represents the closest approach to that end which industrial physicists are likely to encounter, in the case of ferromagnetism at any rate. It is to be strongly recommended to all who need a sound knowledge of the magnetic properties of materials, and one can only regret that its high price

will undoubtedly restrict its circulation in Great Britain.

One final word—Is the magnetic potentiometer really such an unimportant instrument in the eyes of our more technical colleagues that it should be almost entirely ignored? Ewing completely ignored it, and Bozorth gives it about ten lines.

L. F. Bates

APPLIED MECHANICS FOR ENGINEERS

Applied Mechanics for Engineers

By Sir Charles Inglis. Pp. xii+404. (Cambridge: At the University Press, 1951.) 42*s*. net.

When an authority of the eminence of the late Sir Charles Inglis writes a text-book on "Applied Mechanics for Engineers", it is natural to expect a work combining technical perfection with lucidity of exposition. These expectations are fully justified. The book is based on lectures given over a number of years to students working for an honours degree in engineering in the University of Cambridge, but it is also addressed to the average student, whose many difficulties are fully understood and sympathetically resolved.

The presentation of the subject of applied mechanics to engineering students offers wide scope for diversity of treatment. Throughout this book the ideal aimed at by the author has been to keep mathematics as a servant and not allow it to become a master. Thus graphical methods, intelligent approximation and step-by-step solutions of differential equations all receive attention. Even in vibration problems where "that vague commodity known as common sense may be an untrustworthy guide", methods of solution are used in which "the physical aspect of the problem is not obscured by the mysticism of an ingenious mathematical technique".

The book, unfortunately perhaps, is not an omnibus treatise on applied mechanics, since fluid mechanics and strength of materials are omitted. The first six chapters deal with the general conditions of equilibrium and their application to problems in statics, taut cables and catenaries, and the stresses and deformation of frameworks. Then follows a chapter on the friction between dry surfaces.

The remainder of the book forms a masterly, lively, and very readable treatise on engineering dynamics. Two chapters are devoted to basic particle dynamics and kinematics, followed by an introduction to simple harmonic motion and harmonic analysis. Circular motion, up to compounding of angular velocities, is then treated. Two-dimensional rigid dynamics is introduced, followed by chapters on the principle of energy and momentum. The field is now set for the next four chapters on mechanical vibrations, covering forced and damped vibrations, torsional oscillations, coupled systems and aperiodic cases. The final chapter, on gyroscopic principles and applications, as would be expected, is a classic of its kind. Mechanisms have been deliberately omitted; but the exclusion of balancing of multi-cylinder engines is surprising as this type of problem lends itself to the combined analytical and graphical treatments which the author so strongly advocates.

A valuable feature is the number of problems set for solution, which occupy about one-fifth of the book. A few of these examples might be thought to be somewhat removed from engineering practice; but there is no doubt that any student who can successfully solve them all is well equipped for his professional career.

Sir Charles Inglis obviously enjoyed writing this book and has set a high standard to which the publishers have responded. Only a few minor slips in references to diagrams were noted. The work is a most valuable and welcome addition to the literature, well worthy of study by student and teacher alike.

A. S. T. Thomson

CHEMISTRY IN WAR-TIME GERMANY

American Fiat Review of German Science, 1939–1946

Vols. 34 and 35. Theoretical Organic Chemistry, Part 1. By Walter Hückel (senior author) and F. Seel (co-author). Pp. ix+213. Theoretical Organic Chemistry, Part 2. By Walter Hückel (senior author) and J. Goubeau, G. V. Schulz and G. Scheibe (co-authors). Pp. xi+221. Translated, edited and published in cooperation with the Office of Technical Services, Department of Commerce, U.S. Government. (Petersburg, N.Y.: The O. W. Leibiger Research Laboratories, Inc., 1950–1951.) 5.30 dollars each vol.; subscription for 88 vols., 400 dollars.

Immediately after the Second World War a very considerable effort was made by the Western Allies to learn how German industry had been conducted during that period. The comprehensive reports (B.I.O.S. in Great Britain), when critically pieced together, give an adequate account of technology with an occasional reference to more purely scientific work. The Allied Governments wisely realized that it would be just as valuable, if not so urgent, to obtain similar information on the progress of pure science. This could not be conveniently done by sending teams of academic experts to explore university laboratories. It was therefore a much happier idea to let the Germans do the job themselves at a period when it was difficult to continue their old work and initiate new ventures. The present volumes under review are part of a very large undertaking covering pure science and medical science, in which leading German authors have given an account of war-time work in Germany. No less than eighty-four volumes have been so prepared in the German language and submitted to the relevant military authorities. These have now been translated into English by the Leibiger Research Laboratories through the co-operation of the Department of Commerce of the United States Government.

The two volumes under notice cover what is called theoretical organic chemistry, or rather physical organic chemistry as it is now understood in Britain. Since the reviews cover the period 1939–45, they are now to some extent of historical interest because the field is one in which rapid advances have been made, and therefore these reviews cannot be taken as representing the present state of affairs.

As might be expected, W. Hückel plays the leading part, with the assistance of a large number of collaborators. Space will not permit even a detailed list of the topics discussed. In the first volume

Hückel covers a very large field in describing generally not only the structure of organic molecules but also much of the work on reactivity, rearrangements and the like. Stereochemistry gets a whole chapter to itself. F. Seel contributes a chapter on the triphenyl methyl type of free radicals and discusses in some detail those molecules which can exist as di-radicals. Hückel concludes the volume with a chapter on substitution, addition reactions and rearrangements.

The second volume deals with dipole moments and the relationship between physical properties and molecular constitution. G. Scheibe writes on the absorption spectra of conjugated compounds, and J. Goubeau on Raman spectra, while G. V. Schulz finishes off with a chapter on the mechanism of addition polymerizations—a section where there has been a complete transformation since the end of the War. Reading through the volumes as a whole, it is surprising to find how much pure science was, in fact, done in Germany during the War. It is equally surprising that during that period the authors appeared to be unaware of what was going on in other countries, presumably owing to lack of current literature. It is very difficult to write scientific history of this kind, especially as the author now knows of recent developments; and it is therefore natural to find in many places, not only in footnotes but also in the text, references to more recent work so that the author may continue the discussion and bring it more in line with up-to-date ideas. Even though it is necessarily a one-sided effort, the ideas, the method of approach and the arguments provide a fruitful ground for further thought and further development.

The translation in many parts is not well done, and some of the terms are translated into English which would be quite unintelligible to anyone except an expert in the field. Sometimes in the theoretical section the translation is so literal that it is again difficult to follow the line of argument. The volume is litho-printed, which is not as satisfactory as the conventional method of reproduction; but presumably the main excuse is that the cost of production must be kept down to an absolute minimum.

H. W. Melville

FRESHWATER ALGÆ

Algae of the Western Great Lakes Area, exclusive of Desmids and Diatoms

By G. W. Prescott. (Bulletin No. 31.) Pp. xiii+946. (Bloomfield Hills, Mich.: Cranbrook Institute of Science, 1951.) 10.50 dollars.

THE Great Lakes region of North America with its great variety of lakes, swamps and marshes is an especially suitable location for the intensive study of freshwater algæ. In this book, G. W. Prescott has paid particular attention to the diversity of geological formation in the region, with the consequent variety in soil types and in algal distribution. The relationships of the phytoplankton to the productivity of the lakes is discussed, and this section of the book concludes with a summary of the factors that appear to determine the character of lake floras.

Throughout the volume the term algæ has been used in its wide sense, the Euglenophyta and Pyrrophyta being included. Desmids and diatoms have not been described, the former because their great variety is thought to merit special treatment and the latter because they are being studied intensively in the area by another worker.

The varied habitats found in the Michigan and Wisconsin lakes result in a rich algal flora of some thirteen hundred species. The author has attempted to make the list as complete as possible, and therefore records of earlier workers, including those of Gilbert M. Smith's planktonic surveys of Wisconsin lakes, have been included. It would not have been possible in one volume to give a complete description of all the species mentioned; but keys to orders, families, genera and species in each class are followed by notes on the important taxonomic characteristics of each species and by a brief description of reproductive structures where these are of diagnostic importance.

The taxonomic section of the book concludes with a general analytical key to the genera which should prove of value to students, conservators of fresh water, and those less familiar with the classification of the algæ, who might not have the basic knowledge to find their way among the ramifications of the groups in the text. A glossary of technical terms follows, together with a comprehensive bibliography in which the more important works and also those dealing especially with Michigan and Wisconsin algæ are differentiated. The drawings in the one hundred and thirty-six plates are bold and clear; they will be of great use for purposes of identification.

The book will be of value over much of the northern hemisphere, because of the wide distribution of many of the species, and Mr. Prescott is to be congratulated on its clarity and general usefulness. For the benefit of those who are less familiar than the author with the geography of the area, a general map would have been helpful, even if it had been incorporated in the form of end-papers. It would have had especial value if some indication of the geology of the region as well as its physical features could have been outlined.

Lily Newton

CLOWDER OF CATS

Catalogue of the Genus Felis

By R. I. Pocock. Pp. vii+190. (London: British Museum (Natural History), 1951.) 30*s*.

AT the time of his death in 1947 at the age of eighty-four, the late R. I. Pocock was preparing a systematic monograph of the Felidæ; more than once towards the end of his life he had remarked to his friends that he was quite ready to depart, but that he hoped he would be spared to complete "his cats". But it was such an immense task that, although active and working to the end, he was unable to win his race against time. Nevertheless, part of the work was left in a tolerably complete state, and the present volume, dealing with the genera *Felis* and *Otocolobus*, contains all that was ready for publication.

The patient and painstaking care that the author brought to the difficult work of arranging a great number of geographical races in systematic order, and of disentangling the chaotic synonymy, are emphasized by the fact that this catalogue deals with only eight species, seven of them in the genus *Felis*, which are, however, divided into no less than fifty-two named subspecies and three without names. More detailed attention than is customary has been

given to individual skins and skulls because this was the "only means of emphasizing the extent of the individual variations in colour, shape of skull or teeth to which the species or local races are liable". This is fully justified by the careful analysis of the subspecific characters of each race, and zoologists will heartily agree with the author's statement that "realisation of this [variation] is particularly called for in view of the prevalent tendency to regard as deserving of nominal distinction perhaps single specimens differing from one another in trivial characters if inhabiting different localities".

The catalogue starts with a discussion of the characters and subdivisions of the family Felidæ and then deals with each species and subspecies, going fully into the geographical distribution, diagnosis, and skin and skull characters, with numerous tables of measurements and some figures of skulls. The specimens in the collection of the British Museum (Natural History) are listed at the end of each article; but the book is more than a catalogue, for the subspecies not represented in the collections are discussed as fully as the others.

Any species of animal occupying a very extensive range of territory that includes many different kinds of habitat inevitably becomes differentiated into subspecies, and this is well shown by the many races of *Felis lybica* the range of which covers part of southern Europe, the whole of Africa except the thickly forested area, and extends through Arabia and Palestine to northern India and Turkestan. Pocock recognizes twenty-five named subspecies of this cat, and describes three other forms that he regards as separable from the others, though he does not venture to name them. The same phenomenon is illustrated on a smaller scale by *F. chaus* with eight subspecies, and by *F. silvestris* with seven.

A very interesting and unusual section treats of *F. catus*, the domestic cat, a composite form of which the European representatives at least owe their origin to the crossing of two wild species, *F. silvestris* and *F. lybica*. This is a subject to which Pocock had devoted much study and on which he had previously published papers. The tabby pattern of the domestic cat is dimorphic: in the form *torquata*, the 'striped tabby', the pattern consists of comparatively narrow vertical stripes on the sides of the body; in the typical *catus* form, the 'blotched tabby', the broad stripes on the sides show a looped or spiral arrangement and three dorsal stripes run to the root of the tail. The two forms are individually variable; but one or the other can usually be detected in the majority of domestic cats, though the stripes on the body may be entirely suppressed in the *torquata* phase which, Pocock considers, is less stable than the *catus* phase. Pocock does not agree with Schwarz's suggestion that the name *F. catus* should be extended to include the two wild species *F. silvestris* and *F. lybica* as well as all the domestic breeds, because, while admitting the obvious kinship between the last two, he finds no evidence that they intergrade in the wild state. He gives it as his opinion that the *torquata* form of the domestic cat originates from the hybridization of *F. silvestris* and *F. lybica*, and that the *catus* form arose as a mutation from *torquata*. But the whole question of the domestic races is complicated by the widespread occurrence of feral animals that have interbred with the various subspecies of one or the other of the supposed parent species, and perhaps with others; the author discusses these at some length and gives a tolerably full description of feral specimens from all parts of the world.

It is a matter for regret that Pocock did not live to finish his great work or to receive the congratulations of his friends on this valuable instalment. The book is uniform with the new style of Museum catalogues which in format and typography leave nothing to be desired.

THE GREENSHANK

The Greenshank

By Desmond Nethersole-Thompson. (New Naturalist Series.) Pp. xii+244+28 plates. (London and Glasgow: Wm. Collins, Sons and Co., Ltd., 1951.) 15*s*. net.

THIS is a remarkable book, and could have been written by no other person than Mr. Desmond Nethersole-Thompson, who has studied the greenshank more closely than any other naturalist. The secret of the book's success is revealed on p. 98: "Year after year, from late March onwards, our whole lives [the author here refers to his wife, who is at least as skilled an observer as he is] were dedicated to the greenshanks". The author has the good fortune to live in greenshank country, and, as he shows in his book, he has a great love for this bird of the wonderful courtship flight and glorious song. Mr. Nethersole-Thompson is *par excellence* a field naturalist, and many of his observations are entirely new. He is also a good writer, and some of his passages describing the greenshank in its Highland home will linger in one's memory. The reader follows the fortunes of the greenshank from the arrival of the male (who precedes the female at the nesting grounds) through the courting period, and then watches with the author the hatching of the young, the disposal of the egg-shells, and the broods in the pine forests until they fly south in late summer.

A good deal of the book is naturally devoted to the greenshank's song. This is one of the most remarkable—one might perhaps say the most remarkable—of British bird songs. I can bear out the author when he says that the singing bird sometimes flies so high in song that he enters the cloud canopy. One has to watch the greenshank long and closely to hear the full song, which continues without pause minute after minute, the singer all the time flying high in the air, in wide circles, at his topmost speed. It is one of the songs that a great lover and student of birds, Viscount Grey of Fallodon, had long wished to hear and never heard.

There are so many good things in this book that I find it hard to single out any particular part of it for special praise. I can truly say that, as the greenshank has always been a close friend of mine, I should be critical of any book on this species, and it is therefore my tribute that I have nothing but praise for one of the outstanding volumes in the "New Naturalist" series. No bird lover, or bird student, can afford to be without this book, which is superbly illustrated from the photographs taken by a number of leading Nature photographers, who have often been helped by the author. It was, by the way, through his help that Dr. Ludwig Koch was able to obtain recordings of the greenshank's song, and of the hatching calls at the nest, made by parents and young.

Seton Gordon

The Battle for Mental Health

By Dr. James Clark Moloney. Pp. xi+105. (New York: Philosophical Library, Inc., 1952.) 3.50 dollars.

DR. J. C. MOLONEY comes of a well-known medical family, and in his own right he is recognized as a psycho-analyst of eminence. This little book is readable and interesting, but intended principally for lay consumption. It is brought out in the interests of the Cornelian Corner movement throughout the United States and elsewhere, a movement for the return to Nature's methods of infant rearing by the mother as opposed to the modern separation of mother and infant for all purposes but 'ownership'.

Dr. Moloney develops on Freudian lines the complex behaviour, determined by the mother–child relationship, and amplifies his views by anthropological, clinical, scientific and experimental observations. He urges the warmest and most relaxed relationship between parents and infant as a true basis for emotional development. It must be remembered by those in Great Britain and elsewhere who may read this book that the American public is very interested in psychology; in fact, anything that is written or published on this theme is read with avidity.

Analytically minded readers will welcome the book in general; but many will consider it rather superficial in that it fails to give adequate consideration to other environmental influences acting on the child or to the constitutional factors involved. It is well brought out, and there are a good index and many references. K. K. D.

Totem Poles

National Museum of Canada Bulletin No. 119 (Anthropological Series No. 30). Vol. 2: Totem Poles according to Location. By Marius Barbeau. Pp. ix+435–880. (Ottawa: King's Printer, 1951.) 2.50 dollars.

THIS is the second volume of a work the first volume of which has already been reviewed in these columns (see *Nature*, February 16, p. 258). The greater part of Vol. 2 consists of notes on totem poles and other large carvings, arranged by the localities where they were set up; this part is based on Mr. Barbeau's own field-work, supplemented by the writings of others in areas with which he is less familiar. The remainder is called "Synthesis and Compilation" and contains a vast amount of interesting information about the history of the carvings and the techniques employed on them. This part consists very largely of extracts from previous writings, including some by Mr. Barbeau himself, and is extremely valuable in itself; but it would have been more useful still if some attempt had been made to digest it and set out the conclusions in the form of a summary. It is difficult, for example, to extract a clear idea of exactly when the various sorts of large carving developed, and this difficulty is accentuated by the lack of an index, which is only partly corrected by the table of contents. It seems that in Canada large detached totem poles were practically unknown before the nineteenth century, but tall posts attached to house fronts were certainly in existence by 1790, and substantial carvings were seen inside houses by Cook in 1778. There is plenty of evidence of culture contacts with Russian traders for more than thirty years before that, and these may go back further; in fact, it is suggested that the north-west coastal tribes may themselves have come over from Siberia within the preceding few centuries.

We are given some tantalizing hints about the age of the characteristic curvilinear art of the north-west coast of Canada. They include a statement (p. 764) that the earlier work of the Haidas and Tlingits is found in the oldest museum collections of carved argillite and metal, mostly inspired by Chinese and European models, and a quotation (p. 821) from E. L. Keithahn that it was preceded by plain geometric motifs. Some of the art motifs of the Old Bering Sea Eskimos suggest that its origin should be sought in that direction. If the author would pursue the question of the age and origin of this art, he would put us greatly in his debt.

One rather blatant error was noticed. The photographs on p. 838 are repeated on p. 844, and in one case they are labelled Tlingit totems, and in the other Kaigani and Haida ones. They cannot both be right. G. H. S. BUSHNELL

Tycho Brahe, Mannen och Verket

Efter Gassendi översatt med kommentar. Av Wilhelm Norlind. Pp. xxxi+364. (Lund: C. W. K. Gleerup, 1951.) 25 kr.

THE 350th anniversary of the death of the great Danish astronomer, Tycho Brahe (1546–1601), was commemorated by the publication of this book, which is a translation into Swedish of the well-known biography by Pierre Gassendi (1592–1655), entitled "Tychonis Brahei, Equitis Dani, Astronomorum Coryphæi Vita". The first edition of this biography, written in Latin, was published in 1654. This translation, by Dr. Wilhelm Norlind, will make Gassendi's work available to the peoples of Scandinavia.

But the volume is more than a mere translation. A very extensive commentary has been added. Biographical notes about persons mentioned in the text are given, along with much other information that greatly enhances the value and the interest of Gassendi's biography.

A biographical note on Gassendi, an introduction describing briefly the developments in astronomy up to the time of Tycho Brahe, a note on astrological ideas, a glossary for the benefit of non-astronomical readers of astronomical terms used in the book, a detailed bibliographical note, and an index are included.

The volume is an important addition to the literature about Tycho Brahe, and its usefulness would be enhanced if an English translation could be published. It is well printed and contains a number of illustrations. H. S. J.

Jacobian Elliptic Function Tables

A Guide to Practical Computation with Elliptic Functions and Integrals together with Tables of sn u, cn u, dn u, $Z(u)$. By Prof. L. M. Milne-Thomson. (Dover Series in Mathematics and Physics.) Pp. xi+123. (New York: Dover Publications, Inc., 1950.) 2.45 dollars.

ALTHOUGH elliptic functions are useful in many branches of applied science, engineers and others have tended to avoid them because of the illusion that they are difficult to handle. This illusion will be dispelled by Prof. L. M. Milne-Thomson's excellent little volume. This not only gives a useful set of numerical tables, but is also a complete elementary sketch of the application of elliptic functions, starting

from the beginning and intelligible even to those who are previously completely ignorant of the subject. This sketch occupies 39 pages, and includes definitions, the periods and poles, numerical examples using interpolation formulæ, complete elliptic integrals, change of argument and parameter, addition theorems, Jacobi's imaginary transformation, derivates and integrals, Weierstrass's function, elliptic integrals of the first, second and third kind, Zeta functions, conformal mapping, factorization of cubic and quartic polynomials, and applications to the pendulum and to Euler's equations of motion of a rigid body. Then follow 83 pages of graphs and tables of the elliptic functions sn, cn, dn (to five figures), the complete elliptic integrals K, K', E, E' and the nome q (to eight figures), and the zeta function (to seven figures). Should an isolated value of sn, cn or dn be required to more than five figures, it can be found from the series given on p. 13.

H. T. H. Piaggio

Theory of Groups and its Application to Physical Problems

By S. Bhagavantam and T. Venkatarayudu. Second edition. Pp. xiii+277. (Waltair : Andhra University, 1951.) 20 rupees.

THE first edition of this book has already been reviewed in *Nature* (163, 620; 1949), and the second edition differs from it in the following points. The account of one- and two-dimensional lattices is now expanded into two chapters; this was previously contained in one chapter. In the chapter on matrix groups, a section on Kroneker square and symmetrized Kroneker square representation, and Kroneker direct product of two representations, is added. A chapter on molecular structure and normal modes is inserted, and some slight additions are made in the chapters on vibrations of a dynamical system, on molecular structure and normal frequencies, on vibrations in a crystal lattice, and on the application to problems of atomic spectra. Finally, a new chapter is inserted on crystal symmetry and physical properties, and some alterations are made in "other applications".

The effect of these additions and alterations is certainly to improve this useful book.

R. G. Cooke

Advances in Radiochemistry

And in the Methods of Producing Radioelements by Neutron Irradiation. By Dr. Engelbert Broda. (Cambridge Monographs on Physics.) Pp. xi+152. (Cambridge : At the University Press, 1950.) 15*s*. net.

THIS excellent little volume by Dr. E. Broda is a recent addition to the "Cambridge Monographs on Physics" series. It is appropriate that this book should be found among physics texts, for the close connexion between radiochemistry and nuclear physics has never been so evident as to-day. Indeed, Dr. Broda's monograph will probably find its maximum value among nuclear physicists, who may through reading it be inspired to attempt for themselves some of the more elegant radiochemical techniques for the production of pure sources of radioelements at high specific activities (for example, by the Szilard–Chalmers reaction).

For other natural and applied scientists who would gain a speaking acquaintance with the relatively new radiochemical methods, the book provides a good introduction. The author has included chapters which review the fundamental procedures of nuclear chemistry (carrier precipitation, distribution between solvents, volatilization and active deposits, electrochemistry, the production of nuclides by nuclear bombardment, and recoil effects) as well as chapters of general interest (fission, new radioelements, new measurement techniques). Much historical material is summarized, and the book is well laced with references.

The typography is of the high standard which we have come to expect of the Cambridge University Press, and errors are few. However, credit for the naming of element 61, promethium (p. 96), should have been given to Mrs. Charles Coryell, wife of one of the co-discoverers.

Garman Harbottle

The Bird

Its Life and Structure. By Gertrud Hess. Translated from the German by Phyllis Barclay-Smith. Pp. 244. (London : Herbert Jenkins, Ltd., 1951.) 18*s*. net.

THE widespread interest in birds is reflected in the ever-increasing number of books about them. We here have one by Gertrud Hess, translated from the German by Phyllis Barclay-Smith. It deals with many aspects of bird-life from structure to behaviour, including migration, reproduction, nest-building and so on. The illustrations consist of a profusion of pen-and-ink sketches by the author which are very helpful to the text: for example, Fig. 114 of a common heron striding through the grass, and the line drawings on the next page; Fig. 115, of water birds, showing how gulls, being lighter, float higher in the water than ducks. There is an interesting chapter on the ancestry of birds, and at the end of the book some useful tables giving comparative figures for body-weight, heart-weight, temperature, etc. These remind us how hot-blooded a creature is the bird, temperatures of 109° F. or more being common. The "Length of Life" table could do with revision. Forty to fifty years is given for the parrot under the heading of greatest age in captivity, but there are well-authenticated cases of parrots living much longer. But such are minor points in a book which will provide the budding ornithologist with a great deal of useful information.

Frances Pitt

Traveling Waves on Transmission Systems

By Prof. L. V. Bewley. (General Electric Series.) Second edition. Pp. ix+543. (New York : John Wiley and Sons, Inc.; London : Chapman and Hall, Ltd., 1951.) 96*s*. net.

EIGHTEEN years have elapsed since the publication of the first edition of this mathematical treatment of the effects of lightning surges on electrical power transmission lines. It is natural, therefore, that in the second edition of the book there should be some increase in scope and more complete solutions to many problems.

Much of the additional material, in particular the provision of exercises for the reader, has been included to satisfy the needs of the student. In the text the derivations of solutions to differential equations and other mathematical processes are presented in detail, no doubt with the same object; but the detail tends at times to disturb the continuity of the exposition and to obscure the physical arguments. However, the techniques for the solution of practical problems are clearly defined and the book is one of the most comprehensive treatments of the subject and valuable to both the student and the engineer.

THE BRITISH NORTH GREENLAND EXPEDITION, 1952–54

By R. A. HAMILTON
Chief Scientist

WHEN the British North Greenland Expedition leaves for Queen Louise Land in July, it will reawaken the country's traditional naval and scientific interest in polar exploration on a scale not seen since Scott's last expedition. Travelling first by ship to Young Sound on the east coast of Greenland at 74° N. and thence by air, it will establish its main base on the shores of a lake surveyed last summer by a small reconnaissance expedition at about lat. 77° N., long. 24° W. Queen Louise Land is really a series of nunataks consisting of a mountain range protruding from the inland ice which, as well as intersecting it by a number of glaciers, flows round to north and south, and isolates it from the coast, from which it is separated by two glaciers twenty miles wide which flow down the east side and meet in Dove Bay. Thus Queen Louise Land has for a long period of time been isolated from the coastal strip; but it is believed that, although during the Quaternary ice age the inland ice reached farther east than at present, the higher mountains were probably never entirely covered but remained as nunataks with their tops protruding through the ice.

In geology, the primary object is to make a thorough examination of the structure and petrology of the land forms throughout the area. Geographically, the mountain range is thought to be part of a Caledonian folding, much of which is covered by the inland ice, but which is exposed in the Franz Joseph Fjord farther south where there are two belts of younger pre-Cambrian rocks, the Eleonore Bay formation in the outer fjords and the Peterman formation in the nunataks behind the innermost fjord heads; between them a gneissic zone is encountered. It will be of special interest to study the northern continuation of what is thought to be the Peterman formation in Queen Louise Land. The investigation will consist partly of an analysis of the tectonic structures and partly of the petrology, and a study will be made of the boundaries between the gneisses and the less metamorphosed rocks. The Koch–Wegener expedition brought back a few samples from the area among which a sample of diabase was found, which indicates that igneous rocks also may well be present.

Air photographs have recently been made of the area, so the work of the surveyors will consist mainly in setting up a triangulation in Queen Louise Land and linking this to the triangulation in Germania Land on the east coast, which was mapped by the *Danmark* expedition. The heights above mean sea-level must, however, be measured with greater accuracy than is usual in Greenland, as one of the nunataks to the west of Queen Louise Land will be the starting-point of the line of levels to be carried across the ice-cap, and it is hoped that its height will be determined with an error of only one or two metres.

The main interest of the expedition, however, lies not so much in Queen Louise Land itself but in the northern half of the Greenland ice-cap. As soon as the expedition is safely established at its base on the shore of the lake, a sledging party will set off inland to meet an aircraft flying in from the west coast at a rendezvous at about lat. 78° N., long. 40° W. The aircraft will drop a hut, stores and petrol, and an Ice-cap Station will be established which will form the base from which the parties surveying the ice-cap will operate and at which meteorological and glaciological work will be carried out.

The recent work of Expéditions Polaires Françaises under the leadership of Paul-Emile Victor, and theoretical work by Dr. J. F. Nye, of the Cavendish Laboratory, Cambridge (summarized in an article in *Nature* of March 29), have stimulated scientific interest in extensive ice-fields. From mechanical considerations, Nye derives the simple relation that the thickness of a moving ice-sheet is inversely proportional to its surface slope, irrespective of the slope of the bed of the ice-cap. This can be verified by a survey of the surface of the ice-cap and of its bed.

The ice-cap will be surveyed by two different teams of four men and three mechanical vehicles towing sledges. The gravimetric team will move slowly from the edge of the ice near the base camp, measuring the value of gravity at intervals of about four kilometres, and at times making short lateral traverses normal to the track to measure the gradient of gravity. In order to interpret the readings of the gravimeter, the height above mean sea-level at each point must be known as accurately as possible. It is necessary, then, to run a line of levels from Queen Louise Land, using either a levelling instrument or a theodolite over distances not exceeding two kilometres. This work is likely to be tedious and slow, and must be carried out with great care owing to the excessive refraction that occurs in quiet conditions on the ice-cap. When completed, however, the gravimetric survey will give an accurate profile of the ice-cap surface and a measure of its slope at all places between the ice edge and the Ice-cap Station, and from the value of g and the knowledge of the thickness of the ice, measured by the seismic team, the gravity anomaly due to the underlying geological structure can be determined.

The seismic team will move more rapidly and will cover most of the northern half of the ice-cap during the first summer. Based on the Ice-cap Station, it will travel in a series of triangles and will measure the thickness of the ice sheet by seismic methods at 20-km. intervals. The heights of the ice-cap at each point will be measured by aneroid pressure, controlled by a barometric pressure at the Ice-cap Station and a 700-millibar constant-pressure chart of the Greenland area. The seismic survey will thus give a general map of the contours of the bed of the ice-cap, while the gravimetric survey will give an accurate survey along a single traverse. It will be of greatest interest to find whether the bed of the ice-cap in the north-west is as low as 1,200–4,200 metres below mean sea-level, as estimated by Nye. This estimate is based, however, on the existing maps giving the contours of the surface of the ice-cap, and these may well be inaccurate, as they are based only on the aneroid heights determined on the traverses of Rasmussen to the north, and of Koch and Wegener to the south, a distance of nearly 600 km. apart. It is based, too, on the assumption that the ice sheet is moving; but, as Nye says, in the centre of a large ice sheet of considerable height, the precipitation may not be sufficiently in excess of the wastage to keep the mass moving, in which case the height

would be determined by meteorological factors. It is possible that precipitation at this Ice-cap Station will be considerably less than at the French ice-cap station some 400 miles farther south, for the Ice-cap Station will be a greater distance from the track of depressions as they move north-eastwards along the east of Greenland and north-north-westwards up the Davis Strait.

The meteorological programme for the first year consists of the development of instruments and of micro-meteorology in conjunction with the glaciological research, which will be concerned mainly with the subject of regime. Accumulation and ablation will be measured at the Ice-cap Station and at two places on one of the marginal glaciers, one in the ablation and one in the accumulation area, where micro-meteorological stations will be set up. Accumulation will be measured at a dozen places on the glacier and at a number of places on the route to the Ice-cap Station. Accumulation in past years can be estimated by an interpretation of the profile of pits dug in the firn, and the penetration of temperature waves into the ice will be examined by temperature measurements in the ice. Ablation will be measured at intervals at several places on the glacier and on the ice-cap, and over short periods will be related to the radiation and to the vertical gradients of temperature, wind and humidity. The movement of glaciers will be studied in detail.

In order to study the propagation of radio waves across the polar regions, a programme of listening to European broadcasts over a range of frequencies at different times of day has been drawn up; further, if finances permit, soundings will be made of the ionosphere and measurements made of ionospheric winds.

The physiologist will study the acclimatization to cold by the members of the Expedition, will record variations of body temperature, especially during the Arctic night, and changes in basal metabolic rate. Experiments on nutrition, too, will be carried out.

The research programme for the second year depends on the financial position of the Expedition. The survey, and perhaps the geology, will be finished during the first year; but the glaciological programme is planned for two years, and the gravimetric survey will be continued to the west coast. The seismic party will finish the survey of the ice-cap by pushing farther towards Melville Bay, and an attempt will be made to investigate the nature of the rock beneath the ice-cap by refraction methods of seismic survey. Deep drilling will be attempted and, unless prevented from doing so by the plasticity of the ice, it is hoped that the depth will be reached at which the vertical temperature gradient in the ice becomes negative; the temperature and winds in the upper atmosphere will be measured to examine the effect of the Greenland ice-cap on the general circulation.

It is a sign of the times and of the nature of modern scientific expeditions that, in order to carry out their project, the sponsors have found it necessary to build up a novel form of combined operation. In the field, the work will be purely scientific; but the scientists will be assisted by young officers from the Services, who will thus gain valuable training and experience. A combined Service and scientific enterprise of this nature offers advantages to all concerned which none of the supporting bodies could realize alone except at a much greater cost. It is hoped that this happy marriage of men of arms and science may be the pattern for future expeditions of this kind.

PSYCHOLOGICAL AND PHYSIOLOGICAL ASPECTS OF FATIGUE

THE Ergonomics Research Society held a symposium on "Fatigue" at the College of Aeronautics, Cranfield, during March 24–27, at which the psychological and physiological aspects of the subject were reviewed. The 136 persons attending included representatives drawn from universities, the Armed and Civil Services, government research establishments, and private and nationalized industry. Twenty-four of the participants came from abroad.

The study of fatigue has traditionally been regarded as one of the points of close contact between physiology and experimental psychology, although it has been recognized that the problems of the two sciences in this respect are not identical and that the changes of function in peripheral organs which typify what may be called fatigue states at a physiological level are not capable of giving a direct explanation of so-called mental fatigue. Recent advances in both these sciences and in functional anatomy and industrial medicine have, as the papers in this symposium testified, preserved this contact. Manifestations of fatigue are different at different levels, but they display many common principles.

Perhaps the most important of these is that measures of the decrement of overall performance give a very incomplete picture of what happens in fatigue. Often there may be no change in overall achievement or in the adequacy of overall action; but, if detailed measures are taken of the functions which go to make up this total performance, some of them will be found to have changed markedly. The changes are, however, mutually compensatory and so keep the total performance steady. The situation is further complicated by the appearance of side-effects which may become more striking than the main effects which have produced them.

It was probably due to the recognition that the expression of fatigue is complex that few attempts were made at precise definition. Emphasis was laid rather upon the finding of measurable criteria of fatigue and the understanding of the places that these criteria occupy in the process which is being studied. In any normal performance many mechanisms at various levels of function are involved, of which only one or two may show changes with continued exercise. It is clear, therefore, that if a full understanding of what is happening is to be obtained, measurements must be sufficiently detailed to show which mechanisms have undergone a change of function and which have remained unchanged. Such measurements must be taken during performance at the actual task concerned. It is not satisfactory to transfer the subject at intervals from this task to others designed to 'test' fatigue, because he can usually mobilize his efforts to deal adequately with a short test even when his performance at a previous long-term task has shown substantial decrement.

This general position, as it applies to psychological studies, was stated by Sir Frederic Bartlett (Cambridge) in the opening paper. He suggested that the term 'fatigue' should be used to cover all those determinable changes in the expression of an activity which can be traced to continued exercise of the activity under its normal conditions, and which lead eventually to its deterioration. For indication of

these changes, we need to look especially to irregularity in the timing of the different phases of a complex activity, to the tendency for the display field presented to the subject to 'split up', so that he attends to some parts and neglects others, and to the widening of the field of possible responses from which the one to be made is selected—that is, loss of 'control' of the response.

This approach was taken up again at the end of the symposium by Prof. R. C. Browne (King's College, Newcastle) and by A. T. Welford (Cambridge). The comparable approach from the physiological side was presented by Prof. A. Hemingway (Leeds), who pointed out the need for considering a number of different mechanisms interacting to produce a dynamic equilibrium which may be upset in complex ways by a change affecting one mechanism only. A similar type of view was implicit in most of the other papers.

Speaking from the more strictly applied side, Prof. G. P. Crowden (London School of Hygiene and Tropical Medicine) urged that in physiological studies of fatigue it is necessary to consider both the nature of the activity, environmental stresses, the duration and rate of activity, and a number of individual factors.

The use of detailed physiological measures to study the demands of work in industry was demonstrated by Prof. E. H. Christensen (Stockholm), who stressed the need for making job analyses in terms of physiological demand and for considering the capabilities of people of different ages, etc., in relation to the physiological stresses of the working environment.

It is not possible in this article to give any adequate summary of the remaining papers; but they fall roughly into four groups:

Anatomical and Physiological. Some anatomical aspects of fatigue were discussed by H. D. Darcus (Oxford). Reports of research were given by E. Asmussen (Copenhagen) on the extent to which negative work is easier than positive; by H. R. Noltie (Leeds) on 'warming up' in relation to fatigue in athletics; and by J. W. T. Redfearn (Royal Army Medical Corps) on the use of finger-tremor as an indicator of fatigue. H. C. Weston and L. C. Thomson (Institute of Ophthalmology, London) described studies in problems of illumination and posture in relation to visual fatigue, and discussed various factors of difficulty in visual tasks. Films were shown by K. F. H. Murrell (Tube Investments, Ltd.) on the effects of simple devices to aid in the carrying of weights; and by W. H. Floyd (Middlesex Hospital Medical School, London) on electro-myographic records obtained from the *erectores spinæ* during trunk-bending movements.

Psychological. The relative roles of receptor and effector functions in the fatigue of motor skills was discussed by R. M. Gagne (Lackland Air Force Base, United States), and a research on the same subject was reported by W. T. Singleton (Cambridge). Evidence of satiation and frustration as determinants of fatigue was presented by D. Russell Davis (Cambridge), and of the breakdown of ability to reject unwanted sensory information by D. E. Broadbent (Cambridge). A study of the effects of age and heavy work was reported by I. M. Richardson (Aberdeen). Prof. T. A. Ryan (Cornell) and J. L. Kennedy (Rand Corporation) described attempts to obtain measurable criteria of mental effort from muscle action potentials.

Dealing with both physiological and psychological problems were two extremely interesting papers by visitors from the United States: Prof. A. Keys (Minnesota) outlined some of the work he and his associates have carried out on the effects of semi-starvation; and R. S. Schwab (Massachusetts General Hospital) discussed the uselessness of rest as a treatment of fatigue resulting from loss of motivation, and outlined work on muscular performance in normal persons and *myasthenia gravis* patients.

Effects of Heat and Cold. Work on the effects of heat was surveyed by T. Bedford (London School of Hygiene and Tropical Medicine) and by O. G. Edholm (Div. of Human Physiology, Medical Research Council Laboratories, Hampstead). Research on the prevention of heat effects due to impervious protective clothing was described by Prof. G. P. Crowden. Studies of performance under tropical conditions were outlined by Surgeon-Commander F. P. Ellis (R.N. Tropical Research Unit (Medical Research Council), Singapore), and under cold conditions in the Korean winter by W. S. S. Ladell (Colonial Medical Research Service, Nigeria).

Time-and-Motion Study. A discussion on fatigue allowance in time study was led by Prof. T. U. Matthew (Birmingham), who outlined the history and concepts of the subject, and by Prof. J. V. Connolly (College of Aeronautics, Cranfield), who appealed for the co-operation of other men of science in supplying time-study engineers with relevant information. In the subsequent discussion it was urged that physiological measures could be valuable aids in job assessment, provided it was recognized that a performance optimal in one respect might not be optimal in another—for example, a manner of working which involved minimum oxygen consumption might make undue use of a small group of muscles. The need to distinguish between fatigue and boredom was also stressed. Demonstrations of some new time-and-motion study techniques and apparatus were on show in Prof. Connolly's laboratory. A. T. WELFORD

DEVELOPMENTS AND SCIENCE IN THE SOVIET UNION*

By DR. S. M. MANTON (MRS. J. P. HARDING), F.R.S.

IN the summer of 1951 I accepted an invitation to visit the Soviet Union with other scientific workers and directors of medical institutions, where I travelled wherever I wished, accompanied or alone, for ten thousand miles. I belong to no political party or friendship society, and every facility was given to see as much as was possible in a short time, and, in addition, authoritative information was provided at meetings with deputy ministers and directors of various organizations in Moscow, Stalingrad and Tashkent.

Desert and steppe cover one million square miles of the Soviet Union. Twenty-two out of the past sixty-four summers have brought drought to the south Ukraine, and desert conditions prevail over 50 per cent of the central Asian States of Kazakhstan and Uzbekistan, and 85 per cent of Turkmenia. Afforestation schemes were begun in 1948, to be completed within fifteen years, and in 1950 great construction projects were started which by 1957 will

* Substance of a lecture delivered to the Linnean Society of London on February 21.

irrigate seventy million acres, an area equal to that of Britain, Belgium, Holland, Denmark and Switzerland, or one-third of the world's irrigated land. It is thought that this area when watered will produce food for a hundred million persons, as much of it has good soil and enjoys three hundred sunny days a year. The anticipated yields in millions of tons include: wheat, 8; sugar beet, 6; cotton, 3; rice, ½; together with two million head of cattle and nine million head of sheep. Desiccation by wind and movement of desert sand are being checked. The developments of the land will improve the climate over about three hundred million acres, an area greater than that of Europe, and much greater than that to be directly irrigated.

The Soviet Union has need for an abundance of skilled and educated persons, both for the implementation of the great projects and for the improvement in the utilization of the land already under cultivation. Provisions for education have been, and still are, expanding. There are now thirty-three universities which, with other centres for higher education, cater for 1,200,000 students. The old University of Moscow, among the students of which there are eight hundred reading biological subjects, has proved to be quite inadequate, accommodating little more than a third of each year's applicants. A new university building was erected during 1949–51 costing £70 million*. The main block is 850 ft. high with thirty-seven floors, and has one bath-room for every two undergraduate rooms. The perimeter of the main building is 1·7 miles, and nothing is spared in internal decoration and effects. Separate blocks serve chemistry, physics and the biological sciences. The site of 445 acres will also accommodate an observatory, glass-houses and botanic gardens, playing-fields, swimming-bath and park, and seventy thousand trees are being planted. The main building was finished in December 1951, leaving until September 1952 for the installation of £10 million* worth of furniture and equipment. The old university buildings will be used by the arts faculties.

During my visit in the 'long' vacation the universities were not in action; but I saw students, staff and children spending their vacations in the country near Moscow. I visited a holiday centre built by a coal-mining concern at an expense of £300,000, which takes in eight hundred children for three months in the year, and a 'rest home', belonging to an institute of industrial power, for students, staff and little children. In both, every encouragement is given for studies in natural history, rooms being equipped for the purpose, and provision being made for the keeping of pet animals.

The work which I saw in progress in the research institutes concerned with plant breeding cannot be considered fully in a short space. I was impressed by the care with which the work is being carried out, the scale on which many of the experiments are conducted and the results which have been achieved. The wide range of climate and soil over the Soviet Union demands an equally wide variety of economic plants. Methods established by the research stations are put into practice by seventy-two plant-breeding stations each with about four or five thousand acres of land.

Much of the work concerning plant breeding which I saw or discussed with Soviet workers is summarized in "Soviet Genetics", by A. Morton (1951). Scientific workers in the Soviet Union appear to be well aware of the details of the genetical work published in other countries. The amount of Soviet work in progress is so great that, although it is predominantly of an economic nature, the actual bulk of pure science is considerable. Observations by Soviet workers have led them to put forward new genetical conceptions, and the facts upon which these views are based are of fundamental importance and deserve serious consideration. The production of particular varieties of plants has produced interesting side-lines. For example, I examined a plot bearing a wheat with a branched ear, which consequently carried a heavy crop. Most of the plants showed this character, but some, in addition, bore tillers ending in an ear of rye. I was told that each plant had been raised from a single wheat-seed grown separately in a pot and then planted out. Some of the wheat ears showed isolated grains of rye. Prof. M. A. Olshansky said that, when the rye seeds produced on the wheat plant were sown, they gave only rye, the plants having the fourteen chromosomes characteristic of rye. The new areas to be cultivated will be partly irrigated and partly flooded intermittently for pasture. Varieties of crop plants are being produced for use on the new irrigated land, and grasses suitable for the flooded meadows are being selected.

Five major hydroelectric schemes now under construction will have an aggregate capacity of 4½ million kW. Two of the new stations, at Kuibyshev and at Stalingrad, will exceed the largest existing station in the world, with capacities of 2 and 1·7 million kW. respectively. The power will be used for industrial and domestic purposes, for agricultural machinery, such as electric tractors, for pumping water on to the land, and in some regions for artificial rain. Eight enormous reservoirs are being built, together with 44,000 water basins. Hundreds of miles of canals will water both steppe and desert.

Some 3,300 miles of major tree belts are being planted, as a result of twenty years of experiment and research, the total area being more than the arable area of Britain. Lines of trees up to 370 miles long are appearing along the watersheds between the Volga and Ural Rivers, west of the Volga, from Stalingrad to the Caucasus, and across the Don and Donetz. Each consists of trees planted in three or four strips 65 yards wide and spaced 325 yards apart. The effect will be to interrupt the streamlined airflow of the lower atmosphere, substituting turbulence, which will diminish the force of the dry hot winds sweeping westwards from the deserts, and reduce their desiccating power. Much experiment has been needed to establish methods of cultivating trees in the treeless steppe, as was seen at the research stations. Oak is mainly being employed to initiate the forests, because the seedlings develop deep root-systems in dry soil.

Tree lines are being planted on either side of the Ural, Volga, Don and Donetz Rivers for distances up to 670 miles along each. All the small drainage systems around which erosion is so conspicuous from the air are being surrounded by tree lines, many of which were seen for hour after hour during flights over the steppe. Windbreaks on the hedge principle are being planted between the farms. Snow will be retained by the trees, the soil will become moister, the atmosphere damper and erosion will be checked. An abundance of machinery has been devised for the planting of the forests. Every encouragement is being given to increase the bird and insect populations of the new tree belts.

* Taking the rate of exchange as 50 roubles to the pound.

Most of the spring flood water of the Dnieper will be held by two new dams, one across the lower Dnieper below the restored Dnieper Dam, and another across the Molochnaya valley. More than 600 miles of canals will carry this water to the south Ukraine and north Crimea: the daily flow will be about eight times that of the Thames. The Volga-Don Canal is already completed between Kalach and Stalingrad, and ocean-going ships will start using it in May. A dam on the Don at Tsimlyanskaya is completed. A central steel and concrete spillway of nearly half a mile with eight miles of earth wings holds a reservoir 110 miles long. This will supply a network of more than five hundred miles of canals and pumping stations in the lower Don and Kuban regions, part of which will be in operation this spring.

The greater part of the Volga is being converted into a series of lakes. Three dams and power stations are already in operation on the upper Volga, and two larger ones are being built at Gorky, and at Molotov on the Kama tributary. The dams at Kuibyshev and Stalingrad are to be finished by 1955 and 1956 respectively; their reservoirs will be 310 and 375 miles long. The Kuibyshev lake will irrigate a considerable area, and from the Stalingrad lake a canal 375 miles long will carry a flow equal to that of the Don almost to the Ural River. From this canal branches directed towards the Caspian Sea will water an area of semi-desert, equal to that of England, situated between the lower Volga and the Ural Rivers. The Kuibyshev project involves more than twice the earth-work of the Suez Canal, and that of Stalingrad more than three times the earth-work of the Panama Canal. Both dams are being built on silt foundations, which are being stabilized by deep freezing and other methods.

The execution of such gigantic projects, which will in a short time alter the conditions of animal and plant life over so wide an area, is being accomplished by mechanized navvying on an unprecedented scale. The production of the machines is dependent upon the present advanced state of industrial development. Examples of such machines are the 'drag-line' or 'walking' excavator, which digs and dumps eighteen cubic yards of soil a minute, and a suction dredge by which at least half of the necessary excavating is being done under water. A drill, working to a depth of seventy feet, drives the earth to a suction head from which more than a thousand cubic yards of pulp an hour are sucked up and transmitted by a pipe for distances up to two miles. Ten to seventeen engineers on either of these machines can do the work of ten to fifteen thousand men. Twenty suction dredges have been piling up the Tsimlyanskaya dam. Automatic concrete-mixing combines manned by eight to seventeen men can process two train-loads of material an hour, and deliver more than five thousand cubic yards of concrete in twenty-four hours. By these and other machines a labour force of two hundred thousand will, in the next five to seven years, move four thousand million cubic yards of earth, representing sixteen times that shifted for the Panama Canal, and twenty-five million cubic yards of concrete will be mixed, about sixteen times that required for the Dnieper station.

Biological work is in progress on the exploitation of the increased fresh waters. Care is being taken to flood nothing that may prove harmful to fish. Four fish-breeding stations are being established on the Kuibyshev lake and five above Stalingrad. Large stocks of fish are being raised for introduction into suitable waters, and each year millions of fish eggs and fry are put into rivers, lakes and ponds. Six varieties of salmon, two species of trout, sturgeon and other fish are being bred. Special by-passes round the dams are being built for fish, and reservoirs for fish culture. The productivity of salt waters is also receiving attention. The Caspian Sea has become saline by evaporation of river water, and, unlike the Black Sea, its isolation from the oceans has left the Caspian without a normal marine fauna of shrimps and worms. Nearly twenty years ago mullet from the Black Sea were introduced into the Caspian, and they have now multiplied sufficiently to support a fishing industry. Recently *Nereis* was transported from the Sea of Azov into the Caspian, and now the worm covers eleven thousand square miles, providing staple food for sturgeon and other fishes.

The Central Asian deserts are traversed by two rivers, the Syr Darya and the Amu Darya, draining into the Aral Sea. The whole area is becoming dryer. In the third to fourth millennium B.C. a branch of the Amu Darya, the Uzboi, flowed across Turkmenia to the Caspian Sea, and bygone civilizations have left ruined cities and prehistoric irrigation systems in the present deserts. By 1957 it is planned to build a dam across the Amu Darya and to divert nearly half its water, more than five cubic miles annually, into a 683-mile canal running across the Kara Kum desert to Krasnovodsk, together with 746 miles of branch canals. An area of 20½ million acres will be either irrigated or flooded periodically for pasture.

The construction and maintenance of such canals present many problems. Seepage through the bed must be controlled, not only to prevent excessive water loss, but also to prevent the saline subsoil water being raised to a level which would affect cotton and other crops. The evaporation-rate will be very high, and the silt content of the canal water will reach more than twenty million tons. The middle section of the canal will utilize the old bed of the Uzboi River, now carrying salt deposits many feet in thickness. Winds of hurricane force must not bury reclaimed land, nor choke the canal.

In the summer of 1951 an experimental scientific base was established in the Kara-Kalpak, with its own railway line and feed canal to supply water for three hundred scientific workers, for hydraulic machinery and the local growing of crops. A large-scale photo-survey has been made from the air, besides ground surveying to determine the most favourable position for the canal, to locate building material, to determine the subsoil water-levels and their salinity and rates of seepage. Tree belts will be planted on either side of the canals and around the cultivated land, but unlike the steppe, the one and a quarter-million acres of desert forests will have to be irrigated. The black saxaul and poplar grow well under these conditions, poplar and willow windbreaks surround the irrigated lands in the desert oases, and white acacia, mulberry and apricot will be extensively used. Sand-fixing vegetation is being cultivated, and other methods for immobilizing sand are being employed. A reduction in water-level of the Aral Sea, due to diversion of so much water on to the land, will make available large tracts of the rich delta of the Amu Darya for cultivation. Two crops of wheat a year can be raised in Turkmenia, rice and cotton will be grown in the Ukraine for the first time as well as in the Kara Kum, and large numbers of horses and karakul sheep will be reared on the new Turkmenian pastures.

In the summer of 1951 twenty-two parties of biologists were at work in the Kara Kum desert. Each expedition comprised twelve to twenty persons—zoologists, botanists, soil experts and others coming from all over the Soviet Union. Collections of fauna and flora, ecological studies and soil analyses are being made by the expeditions, and particular attention is being paid to the life-cycles of parasites, and possible pests of the new plantations. The young Academies of Sciences in the Central Asian States are taking an active part in their regional economic developments.

The oasis of modern Tashkent is a hygienic city surrounded by farmland with a population of 1,300,000. In 1918 there was no general education, scarcely any medical service, the women were veiled and lacking in social rights, and there was no modern industry. To-day hydroelectric power supplies great industries, and modern buildings in an eastern style are replacing the mud-brick dwellings. "Othello" was being presented in Uzbek in one of the theatres and "Madame Butterfly" in the Opera House. The latter was completed in 1946. I was invited to spend an hour and a half viewing the public parts of this edifice, and it is one of the most beautiful buildings I have ever seen. The emancipation of the women of Uzbikistan is complete, all the children go to school, and there is a university both at Tashkent and Samarkand.

Such advancement has made possible the development of scientific work by the Uzbek and other races. The Uzbekistan Academy of Sciences in Tashkent, housed in a spacious building, integrates the activities of twenty-three research institutes. A visit to the Zoological Institute disclosed a large building with several floors, situated in its own grounds, in which work most of the sixty full-time research zoologists of Tashkent, that is, additional to those zoologists teaching in the University. Many of the zoologists were away on expeditions, some had just returned, and they discussed their work with me. The building contained a sufficiency of apparatus, with a biochemical laboratory and dark-rooms with photomicrographical apparatus. One room was filled with cultures of soil micro-organisms. The economic problems and work connected with the irrigation of Turkmenia and Uzbekistan are engaging most attention at present, and the results of this work are being published in Uzbek journals as well as in those of Russia.

The diversion of so much water from the Volga and the Amu Darya on to the land will lead to a reduction in level of the Caspian and Aral Seas, and if nothing is done an appreciable increase in salinity will occur by 1970. The magnitude of the present construction projects dwarfs anything hitherto undertaken by mankind; but only part of the potentially fertile land in central Asia will be watered. Plans are already under consideration for the diversion of some of the abundance of water flowing into the Arctic seas from the Ob and the Yenisei. The flow on these rivers is more than three times as great as that of the Volga, and much of this water could be diverted to Central Asia by dams, canals and existing dry-river valleys. The Aral Sea could become fresh, and there would be an abundance of water for the Central Asian States.

The new University of Moscow, standing on the Lenin Hills, is a conspicuous landmark visible from the south before any other feature of the city is discernible. This building, which will serve the advancement of science, is symbolic of parallel facilities elsewhere. The University, the towns which are already rebuilt and the great construction projects are clearly designs for peace, and with the medical services, which lead the world in the appreciation of preventive principles*, must represent a very large proportion of the national effort. A fuller account of these and other aspects of my visit will be found in a forthcoming book, "The Soviet Union Today, a Scientist's Impressions".

* See a forthcoming report by Dr. H. Joules *et al.*

OBITUARIES

Prof. N. V. Sidgwick, C.B.E., F.R.S.

Nevil Vincent Sidgwick was born in Oxford on May 8, 1873, the eldest son of William Carr Sidgwick, Fellow of Merton; after his early education at Rugby he went to Christ Church as a scholar in natural science, where, having worked three years under Vernon Harcourt, he took a first in chemistry, following this two years later with a first in Greats—a noteworthy feat. He then worked under Ostwald in Leipzig and with H. von Pechmann in Tübingen, leaving with an Sc.D. of the highest class to return to Oxford in 1901 as Fellow and Tutor of Lincoln College.

For a few years his interests were almost wholly in Oxford, where he followed a rigid routine. Every occupation had its allotted periods, and even his engagements with walking or golfing partners were made for a whole term at a time. His name first became generally known on the publication of his "Organic Chemistry of Nitrogen" in 1910—a book so outstanding in matter and style as to attract attention and praise from all quarters. Personal contacts made during a visit to Australia with the British Association in 1914, and in the course of conspicuously successful work on diverse problems for the Department of Explosives Supply during the First World War, paved the way to a less cloistered life. After the War, he began to take part in the work of scientific societies, sought the acquaintance of eminent British and foreign men of science and, induced by the marriages of pupils and colleagues to break his earlier habit of avoiding any but male society, entered into intimate family friendships, highly valued by both sides.

Sidgwick's researches in the period 1907–20, on rates of reaction, and on the variation of the physical properties of isomeric benzene derivatives with the positions of the substituting groups, followed the usual lines of such work. But in 1920, his mind was so profoundly influenced by the interpretation of the Periodic Classification reached independently by Bohr and by Bury on the basis of the Rutherford–Bohr atomic model that the direction of all his further work was determined. This advance, it was generally realized, opened up the prospect of a rationalization of chemical theory: it was Sidgwick's great merit that he was foremost in turning the prospect into a reality. Few scientific books in modern times can have had such a vitalizing effect as his "Electronic Theory of Valency", published in 1927. This he followed up with intensive studies of the properties directly dependent on the nature of the chemical bond—atomic radii, dipole moments, bond-strengths, valency angles and configurations—writing and lecturing on these subjects with such

force and lucidity that on all he was regarded as authoritative. His Baker Lectures delivered at Cornell, published in 1933 as "The Covalent Link in Chemistry", amplified some of his original ideas. His last and greatest work—no less than the reconsideration of the whole of descriptive chemistry not specifically organic, in terms of modern theory—was published in 1950 as "The Chemical Elements and their Compounds". This, in fact, is the "second volume" projected in his preface to the "Electronic Theory of Valency". It was characteristic of Sidgwick that, despite the magnitude of the task, the distraction of the war years, and the physical disabilities that overtook him, he completed his original plan.

Inevitably, Sidgwick was drawn into the work of important committees and called to high office. At various times he was chairman of the Chemistry Research Board of the Department of Scientific and Industrial Research; chairman of the Publication Committee of the Chemical Society; president of the Faraday Society; president of the Chemical Society; and vice-president of the Royal Society. In Oxford he became successively reader and professor, was a member of the Delegacies for the Clarendon Press and the Bodleian Library, and worked indefatigably for the development of scientific studies. In his work as a teacher, his pupils in Lincoln College naturally took first place; but through informal and easy contacts with men from all colleges, in the laboratories and in the Alembic Club, he became almost a 'Father in Chemistry' to the whole Chemistry School—strict, but not severe, and to be counted upon for help or advice.

Sidgwick was superbly equipped with an acute and penetrating intellect, a memory for many years infallible and a command of apt and elegant language. But even more than these great gifts, it was his intellectual integrity, his life-long refusal to be content with anything but the best, that moved men everywhere to admire and trust him. On any subject, at any time, Sidgwick wrote or said exactly what he thought, in language admitting of no doubt. If, at times, he was caustic in censure or disapproval, his criticisms seldom caused more than passing resentment, so obviously did they arise from his zeal for truth and efficiency. He loved good talk; his own—a unique blend of knowledge and wisdom, wit and anecdote—delighted his company, and stimulated response. He was at his most genial, perhaps, in the Common Room at Lincoln or as host in his own rooms; hospitality, for which the amenities of his College gave such excellent facilities, was one of his greatest pleasures.

Sidgwick travelled widely, but after his tenure of the Baker Lectureship at Cornell University in 1931, where he was delighted with the cordiality of his reception, he returned again and again to the United States. He made friends in universities and research institutions all over the country, many of whom, when they came to Britain, were his welcome guests in Oxford. No man did more than he to promote understanding and friendship between American and British men of science. His visit to the United States in 1951, which, notwithstanding physical disabilities, gave him keen pleasure, was, in fact, his last activity.

Sidgwick lived a full life in the surroundings he most loved; he finished the work to which he had set his hand, and received the rewards he most desired. Not all our thoughts on his death need be sorrowful.

T. S. Moore

Sir Leonard Hill, F.R.S.

Sir Leonard Hill, physiologist, scientist, writer and artist, died peacefully in his sleep on Sunday, March 30, in his home at Corton, near Lowestoft, in his eighty-sixth year.

Leonard Erskine Hill was born on June 2, 1866, and was educated at Haileybury and University College, London. He qualified in medicine in 1889 and received his London M.B. in 1890. After studying under Sir Edward Schafer he taught at University College, London, and later became professor of physiology in the London Hospital Medical School.

Hill's approach to physiology was always such as to establish immediate connexion between phenomena in the cells, muscles, or organs under investigation and the entire living body—his physiology was essentially 'applied'; and applied to the unusual extent in being carried on from the man into his working environment. The environment was in due course to be subjected to physical modifications requisite for the well-being of the man. In this way Leonard Hill may be said to have been the pioneer of health engineering, a profession now recognized in the United States of America.

Hill's wide knowledge, added to his insight into physical and mechanical process in non-living material, gave him an inventive genius of no mean order. He invented the sphygmomanometer independently and almost simultaneously with Riva-Rocci and was only forestalled in prior publication by mere chance. He was one of the pioneers in the physiology of man when working in air under pressure and in the study of the hazards encountered by men when working in diving dress or in caissons. Hill may be credited with the control of caisson disease ('bends') from which divers suffer, by introducing methods of decompression and recompression for these men when coming to the surface from great depths; and he also advocated that divers should perform muscular movements during decompression to assist the liberation of nitrogen from the blood stream.

Afterwards, and while director of applied physiology in the National Institute for Medical Research, Hampstead, Hill became actively interested in the theory and practice of ventilation. In a classical experiment carried out at the London Hospital (when seven medical students were confined in a telephone box), he finally disproved the theory that subtle organic poisons are given off with expired air. Hill's thesis, now universally accepted, that the discomforts and disabilities arising from bad ventilation are more often due to physical causes than chemical resulted in the development of the kata-thermometer and a wide application of its use in field investigations of all kinds. These studies were summarized in Medical Research Council publications on "The Science of Ventilation and Open Air Treatment", Parts I and II, and later "The Kata-Thermometer in Studies of Body Heat and Efficiency"; their application has ranged from factories to ocean liners.

With the late Dr. J. Argyll Campbell and others of a team, Hill made a number of investigations into sweat-loss, pulse-rate and other physiological changes in function resulting from high temperatures associated with changes in humidity and air movement in a wind-tunnel. This hot wind-tunnel contained a running platform on which subjects could be made to run at fifteen miles an hour.

In researches into the biological effects of ultra-violet radiations, Hill measured and compared the effectiveness of various sources by exposing paramecia to the light from arc lamps and the like in quartz cells cooled by water circulation. By observing the relative times taken by these creatures to stop moving, a measure of biological effectiveness was obtained, before suitable photo-electric cells became available. With Mr. T. A. Webster he introduced a simple approximate chemical measurement of ultra-violet radiation from the sun and sky by which for the first time this quantity was measured in different parts of the world.

Hill was an inspiring teacher, and to work under his direction was an education and a delight. He practised what he preached and was to be seen in Epping Forest in the early hours in all weathers. He loved sea bathing, animals, and country life generally. He took an active interest in science to the last, and during the last few years of his life, living in a farmhouse in Kent, was a constant writer to the press on scientific subjects. He married, in 1891, Janet, daughter of Mr. Frederick Alexander, who survives him with four sons and a daughter.

T. C. Angus

Dr. Thomas Wayland Vaughan

Dr. Thomas Wayland Vaughan was one of the old school of biologists. He built up a world-wide reputation in three distinct fields: as an authority on recent and fossil corals, as a pioneer in the study of certain of the larger fossil Foraminifera, and as a leader of investigations into oceanographical problems.

Vaughan was born on September 20, 1870, at Jonesville, Texas, the son of Dr. Samuel and Annie Hope Vaughan. In 1889 he graduated at Tulane University, Texas, where he read widely, learnt the principles of mechanics and mathematics that he was later to apply in working with sediments and on the problems of dynamical oceanography, and began his interest in stratigraphical palæontology. He taught physics and chemistry during 1889–92 at Mount Lebanon College, Louisiana, but at the same time acquired by field experience that stimulus to ecological research that was to colour all his later work. In 1892 he went to Harvard, where he took his A.B. in 1893, and his A.M. and Ph.D. degrees in 1894 and 1903, respectively. He was connected with the U.S. Geological Survey in various ways from 1894 until 1939, when he retired after being geologist in charge of coastal plain investigations during 1907–23, senior geologist during 1924–28, and principal scientist from 1928. Vaughan was also custodian of Madreporaria in the U.S. National Museum during 1903–23, and associated with it in other ways almost until his death. He became professor of oceanography and director of the Scripps Institution at the University of California, La Jolla, in 1924, retiring in 1936.

Although Vaughan wrote a few papers on Mesozoic corals, his main investigations on the group were on Tertiary and Recent faunas. He quickly established his reputation by his important monograph (actually his Ph.D. thesis at Harvard) on "The Eocene and Lower Oligocene Coral Faunas of the United States", published by the U.S. Geological Survey in 1900. Numerous papers followed on fossil corals, notably his large work, "Fossil Corals from Central America, Cuba and Porto Rico, with an Account of the American Tertiary, Pleistocene, and Recent Coral Reefs" (*U.S. Nat. Mus. Bull.*, **103**; 1919). This is important not only for its systematic study of the corals, but also for its stratigraphical correlations and the discussion of coral-reef formation. In connexion with this work Vaughan twice visited London to study West Indian type specimens at the British Museum (Natural History) and the Geological Society.

But Vaughan's interest also embraced modern Madreporaria, and he wrote extensively on them. Monographs and shorter papers covered Floridan, Bahaman and West Indian coral faunas, and those of French Somaliland, the eastern Indian Ocean, Kermadec Islands, and the Pacific Ocean. With such a wide knowledge of corals, Vaughan could scarcely fail to have ideas on their classification. These were crystallized in 1943 in a joint work with Dr. John W. Wells, "Revision of the Sub-orders, Families, and Genera of the Scleractinia" (*Geol. Soc. Amer. Special Paper*, **44**). This revision is based primarily on the structure of the septa, though other skeletal elements are taken into account, as well as the somewhat meagre knowledge of the soft parts. Imaginative in its conception and comprehensive in its treatment, this challenging work is the most important classification of the group which has been made this century.

Investigation of the American fossil corals inevitably led Vaughan to study the problems of sedimentation and correlation of the Tertiary rocks. So he came to pay attention to the early Tertiary larger Foraminifera of the American continent, particularly the orbitoids, which essentially take the place of the nummulites of the Old World. His pioneer researches in this field made a major contribution to stratigraphical palæontology by demonstrating the importance of the orbitoids in correlation and by revealing their evolutionary trends.

Much of this work was published after Vaughan had gone as director to the Scripps Institution of Oceanography, where his ability as organizer and administrator was given full rein. It is to the vision and energy with which he laid the foundations for its present development that that Institution owes its outstanding position in oceanographical research. He was chairman of several committees on various aspects of oceanography, and during 1932–33 made a world tour devoted to the study of provisions for research in that science. One outcome of this was the invaluable "International Aspects of Oceanography" (1937), which he compiled and edited for the U.S. National Academy of Sciences. He also wrote on the ecology of modern marine organisms with reference to palæogeography, and on the classification and nomenclature of the submarine features of the Gulf of Mexico and the Caribbean Sea.

Vaughan's work was widely recognized. The Universities of British Columbia (1933), California (1936) and Tulane (1944) awarded him doctor's degrees. He had been president of a number of societies including the Geological Society of America (1939), which gave him the Penrose Medal in 1946. The U.S. National Academy of Sciences awarded him the Agassiz Medal in 1935 for research in oceanography and the Mary Clark Thompson Medal in 1945 for geology and palæontology. In London he was elected a foreign correspondent of the Geological Society in 1925 and a foreign fellow in 1929, a foreign member of the Linnean Society in 1928, and a corresponding member of the Zoological Society in

1933. The Emperor Hirohito of Japan received him in private audience in 1933, and in 1940 the Japanese Government awarded him the Order of the Rising Sun (third class).

Vaughan's was a lively mind, which was not restricted to the scientific field. He had studied music in Europe, was a life-long admirer of Oliver Goldsmith, and had a high regard for ancient Greek philosophy. He was a generous host, and a willing helper to those who appealed to him in their scientific work. The last years of his life were clouded by seriously failing eyesight and ill-health. His wife, whom he married in 1909, died in 1951, and he himself, at the age of eighty-one, died on January 16 as the result of a stroke. H. DIGHTON THOMAS

Dr. Leonard Dobbin

A LINK with the past has been broken by the death of Dr. Leonard Dobbin, which occurred at Edinburgh on March 3, for Dr. Dobbin was recognized for many decades as one of our leading investigators in the history of chemistry. Born at Belfast on July 30, 1858, Dr. Dobbin in his ninety-fourth year was still actively interested in his favourite field of research—frail in body, but with mind alert and unimpaired.

His early studies were at Queen's College, Belfast, and at the Royal College of Science, London; in 1880 he obtained the degree of Ph.D. at Würzburg and was appointed an assistant in the Department of Chemistry at the University of Edinburgh under Prof. Crum Brown. In 1894 he was promoted to a lectureship, and retired with the rank of reader in 1924.

A number of experimental papers between 1880 and 1893 showed Dobbin's skill as an organic chemist, and his text-book "Salts and their Reactions", written in collaboration first with Dr. Hugh Marshall and later with Dr. J. E. Mackenzie, has been in favour for nearly fifty years. But the historical development of chemistry became his main study, and in 1899 he organized the five non-professorial members of the teaching staff of the chemistry department in the University of Edinburgh into the Alembic Club, an unassuming body which was destined to play a useful part in bringing important chemical communications within the reach of interested readers. The twenty-one "Alembic Club Reprints" now available in booklet form reproduce the classical investigations of the greatest chemists of the past three centuries. Many of these reprints were edited or translated by Dr. Dobbin himself.

His translation of Ladenburg's "Lectures on the History of the Development of Chemistry since the Time of Lavoisier" was published in 1900, and his translation from Swedish and German originals of "The Collected Papers of Carl Wilhelm Scheele" appeared in 1931. These were his two major works; minor contributions elucidating points of dubiety or matters of controversy in chemical history flowed from his pen continually.

Dr. Dobbin was an active member of many scientific societies. He was elected a Fellow of the Royal Society of Edinburgh in 1881, and his seventy-one years of membership probably constituted a record. He served on the Council of the Society during 1904–7 and during 1913–16, was curator from 1934 until 1939, and vice-president during 1939–42. He was also the *doyen* of the Society of Chemical Industry.

One of the most modest of men, and one of the most lovable. JAMES KENDALL

NEWS and VIEWS

Theoretical Physics at King's College, London: Prof. H. C. Longuet-Higgins

THE appointment of Dr. H. C. Longuet-Higgins to the chair of theoretical physics at King's College, University of London, has recently been announced. Prof. Longuet-Higgins, who is not yet thirty years of age, is one of the youngest professors in Britain. The present appointment is particularly interesting as he follows Prof. C. A. Coulson (see *Nature*, 168, 236 (1951) and 159, 632 (1947)), under whom he studied for his D.Phil. at Oxford. Two years after graduating in chemistry at Oxford with first-class honours, he was elected to a fellowship at Balliol. This was followed after two or three more years by a period with Prof. R. S. Mulliken at Chicago. Prof. Longuet-Higgins has been recently in the University of Manchester, where he has been successively lecturer and reader in theoretical chemistry. Prof. Longuet-Higgins's interests are wide. He has made notable contributions to the study of aromatic and conjugated molecules, both as regards their structure and reactivity. While still an undergraduate, together with Mr. R. P. Bell, he helped to revive and develop a bridge model for the boron hydrides and other electron-deficient molecules. He has recently discussed the thermodynamic properties of liquid mixtures and has applied the methods of group theory to molecular vibrations. Prof. Longuet-Higgins is unmarried; he is a keen mountaineer and an accomplished musician, both in conducting and in playing. He will be warmly welcomed in London.

Mathematics at Manchester: Prof. K. Mahler, F.R.S.

DR. KURT MAHLER has been awarded the status of professor of mathematical analysis in the University of Manchester, a mark of recognition of his mathematical distinction that will be welcomed by his many friends and pupils. Dr. Mahler began his mathematical studies in Frankfurt under Prof. C. L. Siegel and, except for some early work on functions of a complex variable, has devoted himself entirely to one aspect or another of the theory of numbers. His first main interest was in the theory of transcendental numbers, and particularly in the closeness with which they can be approximated by rationals with a given denominator. This work led him to consider the extension of the theory of transcendental numbers to the p-adic number-field, and he established a number of important theorems, culminating in his generalization of the Thue–Siegel theorem, on one hand, and his theory of 'pseudo-valuations' on the other. Soon after joining Prof. L. J. Mordell's staff in Manchester, he turned his attention to the geometry of numbers. Taking as his starting-point Mordell's theory of lattice points in non-convex domains, he has in the past ten years published a series of papers in which Minkowski's methods are used for studying the lattice-points of 'star-domains' in two and more

dimensions. Dr. Mahler joined the staff of the University of Manchester as an assistant lecturer in 1937, and except for one short intermission has remained there ever since. He was elected to the Royal Society in 1948.

Royal Aeronautical Society: New President

Mr. G. H. Dowty has been elected president of the Royal Aeronautical Society for the year 1952–53. Mr. Dowty, who is a vice-president of the Society, has been associated with the aircraft and aircraft-component industry throughout his career. Since 1922 he has worked on the development of undercarriages and was the inventor of one of the early deck-landing arresters developed in Great Britain. In 1931 he founded his first company with one man, and is now chairman and managing director of Dowty Equipment, Ltd., and other associated companies in Great Britain and overseas, employing many thousands of people.

Awards

The following medals and prizes have been awarded by the Royal Aeronautical Society: *Society's Gold Medal*, Prof. T. von Kármán, for his outstanding work in aerodynamic theory; *Society's Silver Medal*, Dr. H. Sutton, for his outstanding work over many years on metallurgy in aircraft design; *Society's Bronze Medal*, H. Povey, for his work on the production of the *Comet* aeroplane; *British Gold Medal*, G. R. Edwards, for his outstanding work in aircraft design; *British Silver Medal*, Dr. D. M. Smith, for his outstanding contributions in the development of British gas turbines; *Wakefield Gold Medal*, J. Martin, for his work on ejector seats; *George Taylor (of Australia) Gold Medal*, W. Tye, for his paper on "Modern Trends in Civil Airworthiness Requirements"; *Simms Gold Medal*, H. H. Gardner, for his paper on "Structural Problems in Advanced Aircraft"; *Herbert Ackroyd Stuart Memorial Prize*, Dr. J. Seddon, for his paper on "Air Intakes for Gas Turbines"; *Edward Busk Memorial Prize*, H. Davies, for his paper on "Some Aspects of Flight Research".

Holweck Medal and Prize for 1952: Prof. L. Néel

Prof. L. Néel, of the Institute Fourier, Grenoble, has been awarded the Holweck Medal and Prize for 1952 and will deliver the seventh Holweck Lecture at the Royal Institution, 21 Albemarle Street, London, W.1, on May 27 at 5 p.m., his subject being "Antiferromagnétisme et ferrimagnétisme". The Holweck Medal was founded by the Physical Society as a memorial to Fernand Holweck, director of the Radium Institute, Paris, and to other French physicists who were killed during the occupation of France in the Second World War, and the award is made annually by the Physical Society and the Société Française de Physique jointly. The recipient is alternately a French and a British physicist, distinguished for his work in experimental physics.

New Radio-Telescope for the University of Manchester

The Department of Scientific and Industrial Research and the Nuffield Foundation have decided to provide a steerable radio-telescope for the University of Manchester, the total cost of which (estimated at about £336,000) will be shared equally between the two bodies. The telescope, which has been designed in conjunction with Messrs. Husband and Co. (388 Glossop Road, Sheffield, and 70 Victoria Street, London, S.W.1), as consultants, will be in the form of a paraboloid aerial, 250 ft. in diameter, rotating on a platform 310 ft. in diameter. The height of the aerial, to the top of the horizontal axis, will be 185 ft. and, with the telescope directed horizontally, the total height will be 300 ft. Experimental work in relation to wind pressures on the structure has been carried out at the National Physical Laboratory, Teddington. The total weight of the telescope carried on the rails will be 1,270 tons, and the two main elevating-racks at each end of the horizontal axis have been obtained from the battleships *Revenge* and *Royal Sovereign*, which were recently broken up. The telescope will be set up at the Jodrell Bank Experimental Station, Cheshire, of the University of Manchester, and it is expected that the construction will be started this year and be completed in about four years time. The work at Jodrell Bank is under the direction of Prof. A. C. B. Lovell, with R. Hanbury Brown, J. G. Davies, Dr. T. Kaiser and C. G. Little as his principal assistants, and the main radio-telescope at present in use is a fixed paraboloid aerial 220 ft. in diameter. This research has already benefited from a five-year grant made by the Nuffield Foundation to the Physical Laboratories in 1945, and in 1947 the Department of Scientific and Industrial Research made appreciable grants for the work at Jodrell Bank and also to the University of Cambridge, which is the other principal centre for radio-astronomical research in Great Britain; at the latter the apparatus used is mainly of the interferometric type. The existing radio telescope at Jodrell Bank suffers from the disadvantage of having only a very limited movement, and the new instrument, which will be both bigger and, more important, able to scan the whole sky, should prove to be a valuable research tool in the hands of a department which has already done remarkable work. A recent communication from the Jodrell Bank Station appears on p. 746 of this issue of *Nature*.

Underwater Television

A new field of the application of television was opened up about a year ago when, at the request of the Admiralty, Marconi's Wireless Telegraph Co., Ltd., hurriedly assembled a television camera chain in an attempt to find the lost submarine *Affray*. A great deal of development work has since been carried out in co-operation with Siebe, Gorman and Co., Ltd.; and recently (April 17) a demonstration of the newly designed equipment was given in an experimental tank at the works of this Company. Among the special features of the apparatus shown were the use of the extremely sensitive image-orthicon camera tube, the enclosure of this camera and its associated components in a chamber capable of withstanding the water pressure prevailing at great depths, and the provision of remote-control facilities whereby the camera may be focused and directed by the operator who remains on the ship above. While the experimental tank could not simulate the effects of pressure at great depths, the picture signals were transmitted from the submerged television camera through about 450 ft. of cable to the viewing screen; and this could be extended to 1,000 ft. when necessary. Tests made under practical conditions at sea show that artificial illumination of the object is of doubtful value when the water is clear; but the

equipment is provided with a battery of tungsten-filament lamps, mounted on a suitable framework, for illuminating objects under water at ranges up to 20 ft. from the camera. In the course of the demonstration, the movements of a diver in a normal diving suit, and also of a 'frogman', could be seen in good detail on the television screen. Another important advantage of this method of examining objects on the sea-bed is that the television picture received on board ship from a submerged camera can be photographed and a permanent film-record thereby obtained. This aspect of the technique was illustrated in, for example, the "Television News Reel" shown a day or two after the demonstration.

Rothamsted Manor House

ROTHAMSTED MANOR, the ancestral home of Sir John Bennet Lawes, founder of Rothamsted Experimental Station, has been converted into a hall of residence for members of Rothamsted staff and visiting scientific workers. The south front of this fine house was given its present shape in the seventeenth century; but the building has a history several hundreds of years older than this. The oldest portion of it, the present hall—originally a simple timber-framed structure—dates back at least to the fourteenth or fifteenth century. Around this the owners during Elizabethan times built a typical Tudor country house, decorating some of the walls with mural paintings, one of which, depicting a siege (perhaps of Edinburgh in 1573), is still well preserved. In the 1630's Sir John Wittewronge, whose mother had bought the estate for him, took up residence there. His considerable additions and alterations left the house substantially as we see it to-day, and it remained in the possession of his descendants for three centuries. Sir John Bennet Lawes was born here on December 14, 1814. Some of his early experiments were made in one of the bedrooms, before he set up his first laboratory in a barn on the estate. He added the great drawing-room in 1863, to celebrate the coming-of-age of his son Charles, who in his turn built the single-story library beyond it. In 1934, after a public appeal which met with a very generous response not only in Great Britain but also in many other parts of the world, Rothamsted House and its estate of 527 acres were bought by the Lawes Agricultural Trust. The house remained a private residence until the Second World War, when it was taken over by the Army. Soon after its derequisition, work was begun on the conversion which has just been completed. Six small flats have been constructed at the east end of the main house, in the gatehouse and in the old brewhouse, and about twenty single rooms on the upper stories. Modern kitchens and a residents' dining-room have been built in the seventeenth-century kitchen wing, and barns and outhouses have been adapted to serve as a sample house, a museum and garages. The chief rooms of the main house, however, remain unaltered, and the amenities of the house and its garden have been carefully preserved.

Journal of Rational Mechanics and Analysis

IN January appeared the first number of a new journal, entitled *Journal of Rational Mechanics and Analysis*, edited by T. Y. Thomas and C. Truesdell, and published by the Graduate Institute for Applied Mathematics, Indiana University, Bloomington, Ind. The first number consists of 172 pages and contains the following papers: hydrodynamical existence theorems, by J. B. Serrin, jun.; deformation of sub-spaces in a Riemann space, by V. Hlavatý; elastic stress fields, by P. F. Nemény and W. Sáenz; statistical hydromechanics and functional calculus, by E. Hopf; and the mechanical foundations of elasticity and fluid dynamics, by C. Truesdell. Each volume will contain about six hundred pages, and usually one volume will appear each year. The subscription price is 18 dollars a volume; but a reduced rate of 6 dollars a volume is offered to those engaged in research or teaching. Subscriptions and inquiries should be addressed to the editors.

Society for the Bibliography of Natural History

AT the annual general meeting of the Society for the Bibliography of Natural History, held in the British Museum (Natural History), on April 21, it was reported that a further part of the Society's *Journal*, containing several articles of a miscellaneous character, is in the press. After the conclusion of formal business, members visited the new library quarters of the Department of Entomology of the Museum, where they were received by the keeper, Mr. N. D. Riley; a small exhibition of books and original drawings of entomological interest had been prepared for the occasion. The following officers of the Society were elected: *President*, Dr. J. Ramsbottom; *Honorary Secretary and Treasurer*, A. C. Townsend, British Museum (Natural History), Cromwell Road, London, S.W.7; *Committee*, A. G. Davis, W. N. Edwards, Dr. F. C. Fraser, F. J. Griffin, W. T. Stearn and C. Kirke Swann.

Graduate Science Fellowships of the U.S. National Science Foundation

THE National Science Foundation (2,144 California Street, N.W., Washington 25, D.C.) has recently announced that 624 graduate fellowships in the natural sciences for the academic year 1952–53 have been awarded, of which 569 were predoctoral and 55 postdoctoral fellowships. The successful candidates were chosen from among about three thousand applications drawn from all parts of the United States and its possessions and from United States citizens abroad, and the selection was carried out by the National Research Council, predoctoral applicants being required to take an examination. The distribution of the fellowships according to year since graduation is as follows: first year, 169; second year, 170; advanced predoctoral, 230; and postdoctoral, 55. The awards to first-year graduates represent a departure from the Foundation's previous policy and are designed to encourage students to take up work leading to advanced research. The largest group of fellowships, totalling 158, is for research in the biological sciences, and in other fields the numbers of awards are as follows: chemistry, 140; physics, 137; engineering, 75; mathematics, 62; earth sciences, 36; agriculture, 7; astronomy, 6; and anthropology, 3. Fellows may pursue their training at accredited non-profit institutions of higher education in the United States or similar institutions abroad approved by the Foundation. The value of the fellowships is as follows (in dollars a year): first year, 1,400; second year, 1,600; advanced predoctoral, 1,700; and postdoctoral, 3,000. Second-year and higher fellows receive additional allowances for wives and children. Normal tuition and laboratory fees are paid by the Foundation, and limited allowances to aid in defraying costs of travel are provided.

Overseas Science Students' Association

The Overseas Science Students' Association was formally instituted at a meeting in London on March 19, and about a hundred members have already joined. The proposal that such an Association should be formed was adopted at an earlier meeting on February 27 when Sir Harold Spencer Jones, the Astronomer Royal, addressed a number of overseas science students at the Society for Visiting Scientists. The objects of the Association are to bring graduate science students from overseas into contact with the scientific life of Great Britain and to bring such students into contact with one another. It is affiliated to the Society for Visiting Scientists, Ltd., where its meetings will be held. The Association proposes to fulfil its objects by arranging scientific meetings and visits to places of scientific interest and by other means. The executive committee has been elected as follows: *President*, W. J. De Coursey (Canada); *Secretary*, P. Sen (India); *Treasurer*, Dr. J. Pepys (South Africa); *Members of Committee*, P. Mildner (Yugoslavia), Miss E. H. Nelson (United States), Miss M. E. De Jager (South Africa), M. Ramasamy (Ceylon), Dr. Sutarman (Indonesia) and J. Thabit (Iraq). Further details can be obtained from P. Sen, c/o Society for Visiting Scientists, Ltd., 5 Old Burlington Street, London, W.1.

Institute of Petroleum: New Officers

At the annual general meeting of the Institute of Petroleum, held on April 24, at 26 Portland Place, London, W.1, Mr. H. S. Gibson was elected president for the session 1952–53. Mr. Gibson, who is managing director of the Iraq Petroleum Co., Ltd., and associated companies, was responsible for the negotiations which resulted in the recent signing of the new agreement between the Government of Iraq and his companies. Previously, he had been general fields manager in Persia for the Anglo-Iranian Oil Co., in which organization he had been since 1928. He was awarded the Redwood Medal of the Institute of Petroleum in 1947, in which year he also received the C.B.E. The following elections were also made at the meeting. *Vice-Presidents:* H. Hyams, of the Product Development and Research Department, Shell Petroleum Co., Ltd.; H. E. F. Pracy, general manager, Trimpell, Ltd.; and R. B. Southall, director, National Oil Refineries, Ltd. *New Members of Council:* A. J. Goodfellow, chief chemist, Carless, Capel and Leonard, Ltd.; E. C. Masterson, manager of the Oil Department, Kuwait Oil Co., Ltd.; A. R. Stark, in charge of lubricating oil and bitumen manufacture, Anglo-Iranian Oil Co., Ltd.; and W. H. Thomas, analytical and technical information officer, Sunbury Research Station, Anglo-Iranian Oil Co., Ltd.

Announcements

Sir Cyril Fox, formerly director of the National Museum of Wales, has been awarded the Gold Medal of the Society of Antiquaries, for his distinguished services to archæology.

Dr. A. L. Morrison has been appointed director of research of the Research Laboratories of Roche Products, Ltd., of Welwyn Garden City, in succession to Dr. F. Bergel, who has been elected to the chair of chemistry in the Institute of Cancer Research, University of London.

Dr. Evani Kondaiah, who for the past three years has been working with Prof. Kai Siegbahn at the Nobel Institute, Stockholm, has been appointed a Scholar at the Australian National University, Canberra, and will work with Prof. E. W. Titterton in the Department of Nuclear Physics.

Dr. D. L. Gunn has been seconded to be director of the International Red Locust Control Service, the headquarters of which are at Abercorn, Northern Rhodesia. Since 1946 he has been principal scientific officer at the Anti-Locust Research Centre, London, and before that he was senior lecturer in zoology in the University of Birmingham.

The Weizmann Prize, awarded by the municipality of Tel Aviv, is given for original research work, judged to be the most distinguished of that produced from and in association with Israel, and published not more than two years previously; the first award was made in 1949. Recently two awards have been made, one to I. Dostrovsky, J. Gillis and D. R. Llewellyn, of the Weizmann Institute, Rehovoth, and University College, London, for their work on the separation of isotopes, and the other to L. Bichovsky-Slomnitzki for her work on the influence on bacteria of aromatic diamidines and polyamines.

A symposium on "Micro-Waves and their Relation to Optics" will be held in Milan during June 9–11. The symposium is sponsored by the International Commission on Optics and the International Union of Pure and Applied Physics. It is being organized by the National Research Council of Italy and by the Italian Society of Physics. Further information about the symposium can be obtained from Prof. E. Perucca, Polytechnico, Turin.

The First International Congress of Dietetics will be held in Amsterdam at the Royal Tropical Institute, 63 Mauritskade, during July 7–11. The Congress, which is being organized by the Netherlands Association of Dieteticians, will have as its principal aim the discussion of methods whereby the science of nutrition and dietetics may best be applied to the public well-being. Further information can be obtained from the Council of Nutrition, 42 Koninginnegracht, The Hague.

A summer course in techniques and applications of the electron microscope will be given by the Laboratory of Electron Microscopy of the Department of Engineering Physics, Cornell University, during June 16–28. The course is designed for research workers in institutions or industry who have recently entered the field of electron microscopy or who are planning to undertake research problems involving applications of the instrument. Further details can be obtained from the director of the course, Dr. Benjamin M. Siegel, Department of Engineering Physics, Rockefeller Hall, Cornell University, Ithaca, N.Y.

Erratum. Dr. J. D. H. Strickland writes: "In the communication under the title 'Use of Ion Exchange Resins to determine the Charge of an Ion in Aqueous Solution' in *Nature* of April 12, p. 620, an error occurs in equation (3), which should read:

$$\log \frac{k_1}{k_2 - k_1} = \frac{n_2}{n_1} \log C_B + \log \left(\frac{V}{n_1 \sqrt{K_c . w . \bar{C}}} \right).$$

This in no way vitiates the general conclusions".

PROPERTIES AND PHYSIOLOGICAL ROLE OF ASPARAGINE AND GLUTAMINE, WITH A NEW INTERPRETATION OF THE STRUCTURE OF ASPARAGINE

By Prof. F. C. STEWARD and Dr. JOHN F. THOMPSON*
Dept. of Botany, Cornell University, Ithaca, N.Y.

Discovery, Occurrence and Metabolic Significance of Asparagine and Glutamine

ASPARAGINE and glutamine are the only amides definitely known to occur in plants in quantity. Occurring together and in relatively large amount, they may account for a large part of the soluble nitrogen of many plants, as in the potato tuber[1]. In other plants one or another of these substances is the predominant amide, for example, asparagine in certain legumes[2] and glutamine in the beetroot[3], and there are still other plants, for example, acid sap plants[4,5], in which ammonia predominates over amides.

Through its relation to glutamic acid, manifestly one of the most reactive amino-acids in both the plant and animal body, glutamine, though first familiar to plant biochemists, now also commands the interest of the animal biochemist—particularly in the interpretation of the biochemistry of brain[6]. Asparagine, on the other hand, is prominent only in plant metabolism, where it functions as a reserve substance and often seems to be somewhat more remote from protein synthesis than glutamine[7]. In animals, asparagine seems only to be effective in the formation of protein in the ruminants, where the bacteria take a conspicuous role[8].

The recent report by Hanes *et al.*[9] of 'trans-peptidation' suggests that once the amide link of glutamine is formed, which, to follow an older view[10], may be regarded as a 'hydrogen peptide', it may be readily interchangeable with another amino-acid moiety of a peptide. This suggests the possibility that the enzymic synthesis of the amide linkage of glutamine may prove to be one of the most important single steps in the synthesis of protein.

Asparagine, the 'half amide' of aspartic acid, was discovered by Vauquelin and Roubiquet in 1806. This early discovery in comparison with other amino compounds is not surprising, for asparagine is a relatively stable and easily crystallizable substance, widely distributed as a plant storage product.

It is more surprising that glutamine, the next higher homologue of asparagine, was not discovered until 1883 (even though it is relatively abundant in plants), and its metabolic relations and importance have only become really apparent in relatively recent years (for summary see Archibald[6]). In referring to the differences between asparagine and glutamine the common tendency has been to consider the glutamine to be the more anomalous of the two[6], whereas we believe the reverse to be nearer the truth.

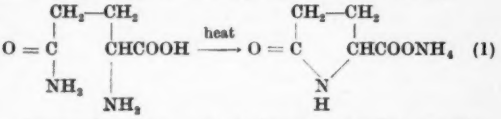
Contrasts in the Properties and Behaviour of Asparagine and Glutamine

Before considering alternative views on the structure of asparagine the following contrasts between asparagine and glutamine should be noted.

(*a*) Glutamine is anhydrous, whereas asparagine crystallizes with one molecule of water. Glutamine, although the higher homologue, is more soluble than asparagine in water (3·6 gm. per 100 gm. water at 20° C. in contrast to 2·1 gm. for asparagine). Asparagine and glutamine do not form mixed crystals. Asparagine crystallizes readily from aqueous solution in the presence of impurities, whereas glutamine does not[1].

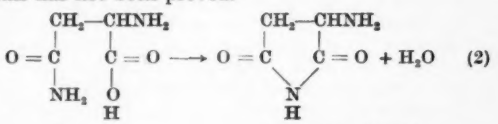
(*b*) Asparagine is stable in neutral aqueous solution and withstands heating to 100° C.; glutamine is readily destroyed in boiling water[11,12]. Both amides are hydrolysed in acid or basic solutions.

The destruction of glutamine in neutral or weakly acid solutions is explained by ring formation with the elimination of ammonia to form the ammonium salt of pyrrolidone carboxylic acid (equation 1).



(1)

Asparagine does not undergo a similar reaction because this would lead to a four-membered ring, which is improbable. Although asparagine might undergo ring formation by elimination of water to form an 'asparagine anhydride' or 'asparaginimide', synonymous with amino succinimide (equation 2), this has not been proved.



(2)

Asparagine

Amino succinimide
'Asparagine anhydride'
or 'asparaginimide'

Although various workers[13,14,15] claimed to have formed 'asparagine anhydride' or 'asparaginimide', Emil Fischer and Koenigs[16] afterwards showed that this was the diketopiperazine formed by splitting water from two molecules of asparagine.

Apparently elimination of ammonia is more conducive to ring formation than elimination of water because glutamine forms the pyrrolidone ring much more readily than glutamic acid does[17].

(*c*) Glutamine is readily hydrolysed by 5 per cent sulphuric acid, whereas asparagine is hydrolysed more slowly. In five minutes at 100° C. the hydrolysis of glutamine is complete: that of asparagine only to the extent of 23 per cent[18]. Presumably glutamine first forms pyrrolidone carboxylic acid, which then hydrolyses to glutamic acid.

(*d*) Both the amide and the amino groups of glutamine react with nitrous acid to liberate nitrogen whereas only the amino group of asparagine reacts in this way (Chibnall and Westall[11]; also see Archibald[6]). One explanation of this difference has been that the amide group of asparagine, unlike glutamine, may be tautomerized to an 'enol' form as follows[11]:

$$—CONH_2 \rightleftharpoons —C(OH)=NH.$$

* Present address: U.S. Plant, Soil and Nutrition Laboratory, Ithaca, N.Y.

(e) The product of the reaction between glutamine and ninhydrin, as this reaction is now carried out on paper, is the same purplish-blue compound which is formed with α-amino-acids. This substance has absorption peaks at 410 and 570 mμ. Asparagine, however, reacts on paper to give a characteristic brown colour with a different absorption spectrum[19] with maxima at 318 and 360 mμ. When the reaction s carried out in the test-tube, asparagine forms the brown colour first, and later, on prolonged heating, it turns blue; glutamine, however, gives the blue colour immediately.

Like all typical α-amino-acids, glutamine liberates carbon dioxide when it reacts with ninhydrin. This is true[20] of asparagine, but only under certain conditions which will be described below, when asparagine reacts like glutamine to give the blue compound.

(f) The deamidases which act upon glutamine and asparagine respectively are quite specific (Krebs[18] and refs. cited in other reviews[1,21]). Though extreme enzyme specificity is familiar, it is still somewhat surprising, in view of the supposed similarity of structure, that the same enzyme would not hydrolyse the amide groups of both substances. In plants, deamidases which hydrolyse each amide are widespread; in animals, deamidases which concentrate upon glutamine, but exclude asparagine, are the rule. This is consistent with the general view that both plants and animals readily synthesize and metabolize glutamine but only plants synthesize asparagine. In view of the rigid specificity of some of the deamidases, one might expect that asparagine would act as a competitive inhibitor for glutamine deamidases and vice versa: this is apparently not so.

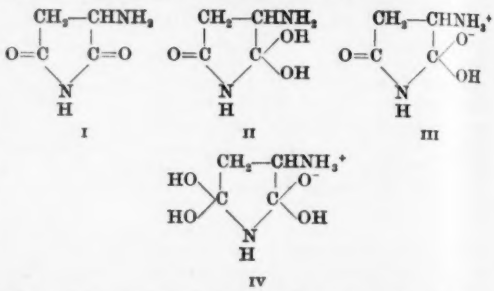
Stumpf *et al.*[22] have recognized an enzyme system in plants which promotes the reaction between glutamine and hydroxylamine; but the corresponding reaction with asparagine does not occur.

(g) There are evident contrasts in the behaviour of glutamine and asparagine in plants. These have been interpreted to mean that glutamine is often more closely connected with protein synthesis than is asparagine, which is to be regarded more as a reserve substance and a store of the nitrogen which accrues from protein breakdown[7] (cf. work of Vickery *et al.*[24,25] there cited). The enzymatic synthesis of glutamine *in vitro* (see refs. cited by Steward and Thompson[23]), with the intervention of adenosine triphosphate as an energy donor; the role of respiration in the *in vivo* synthesis of glutamine; the occurrence of glutamine in protein (zein) both in the form of glutamine peptides and as combined amide, and the recent emphasis by Hanes *et al.*[9] on glutamine and γ-glutamyl peptides (for example, glutathione) as primary products which lead to the derivation of peptide bonds by 'transpeptidation' reactions, all testify to the great interest which attaches to glutamine in its relation to protein synthesis.

Hence, it is evident that the differences between glutamine and asparagine are of kind rather than merely of degree and they are greater than are ordinarily found between two homologues identical in every other way (that is, in the presence and arrangement of three functional groups NH_2, COOH, $CONH_2$ and which differ only in one methylene group). Glutamine and asparagine, therefore, may not be true homologues, and if so the accepted structure for one of them is incorrect. We were, therefore, led to the view that these substances are structurally more different than their conventional formulæ indicate. Regarded as an α-amino-acid, asparagine reacts abnormally with ninhydrin. The concept that the reaction between ninhydrin* and α-amino-acids involves a free carboxyl group (as shown by the decarboxylation which occurs simultaneously) suggested to us that asparagine is cyclic with the carboxyl group combined in the ring. Asparagine and *not* glutamine then would have the anomalous structure.

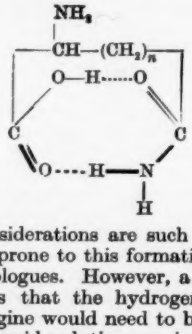
A New Interpretation of Asparagine

The structures now proposed to explain the properties of asparagine are as follows:



I II III IV

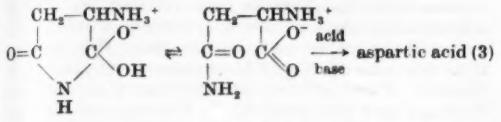
The parent structure (I, amino succinimide) will be recognized as a dehydration product of anhydrous asparagine as conventionally represented; formulæ II and III, therefore, correspond to the empirical formula for asparagine postulating one molecule of water more or less tightly bound as a hydrate, by some type of ionic forces for which there are precedents (for example, in ninhydrin and in amino-acids). This molecule of water is not readily removed by heating and is an integral part of the molecule which probably exists in the form of a dipole such as III or IV. Crystalline asparagine as commonly obtained, with one additional molecule of water of hydration, would now have the symmetrical formula IV. (In correspondence, Dr. M. L. Huggins, of Eastman Kodak Co., suggested an alternative. He visualized that the molecules of the dicarboxylic acid compounds are coiled around to bring the two carboxyl groups into proximity so that, in the half amides, hydrogen bonding may occur between the carboxyl and amide groups as in the formula:



The spatial considerations are such that asparagine would be more prone to this formation ($n = 1$) than any of its homologues. However, a major difficulty on this view is that the hydrogen-bonded amide group of asparagine would need to be stable even to nitrous acid in acid solution, as in the Van Slyke determination[27] for amino nitrogen, if this formula were to explain the difference between glutamine and asparagine.)

* This widely held idea, attributable to Ruhemann[26], cannot be wholly correct since some substances (for example, certain amines) which do not have a carboxyl group also react with ninhydrin to give purplish-blue compounds.

In our view, asparagine in solution should be represented as a tautomeric system as follows (equation 3), in which the equilibrium is far toward the ring form. Any conditions (such as acid, base or ninhydrin in hot solution) which remove the straight-chain form from the solution would cause the ring form to shift towards the straight-chain form.



The conventional formula for glutamine is still regarded as correct because the analogous ring structure (pyrrolidone carboxylic acid) is known to be formed (equation 1) readily from glutamine by the elimination of ammonia. Also, we are aware that Dr. R. Pepinsky has shown, by the combined techniques of X-ray diffraction and electron density, that crystalline glutamine has a straight-chain form (private communication).

This view of the molecular configuration of asparagine explains some otherwise puzzling differences between glutamine and asparagine.

(*a*) The evident failure of the 'amide' group of asparagine to react with nitrous acid is explained by the fact that this group is involved in ring formation and is not free.

(*b*) The evident fact that the brown-coloured product of the reaction between asparagine and ninhydrin on paper is not typical of α-amino-acids is explained by the fact that the ring compound, lacking a free carboxyl, reacts in another way (as, in fact, proline does also).

(*c*) If glutamine and asparagine have basically different structures, it would be expected that this would be reflected in different physiological roles and would be consistent with the extreme specificity of enzyme systems (for example, deamidases, transaminases, transphorylases, etc.).

(*d*) The role suggested for glutamine in the primary synthesis of peptide bonds has not been to the exclusion of asparagine. It remains, however, to be shown whether asparagine can function in a similar manner. It would be consistent with this interpretation of structure if this were not the case so long as asparagine were in the cyclic form. To be contained in a protein, asparagine would need to be combined in the straight-chain form, which might result from enzyme action, or exist only as a terminal group. Alternatively, the asparagine combined in protein might only form by amidation of aspartic acid already combined. In this way, asparagine would arise as a product of protein breakdown.

(*Note added in proof.* The following very recently established facts are also relevant. Certain micro-organisms (*L. arabinosus*) use glutamine and glutamine peptides with equal ease whereas they use asparagine peptides as readily as aspartic acid but *more* readily than free asparagine (Miller, H. K., and Waelsch, H., *Arch. Biochem. and Biophys.*, **35**, 176; 1952). If the asparagine is combined in the peptide in the open-chain form, whereas the free asparagine is cyclic, these results could be explained.)

The physiological significance of the new ideas on the structure of asparagine and glutamine will be apparent. The two substances are not to be regarded as homologues, almost interchangeable in physiological reactions, but substances with different structure and different properties in solution, so that they would be expected to have quite different roles in Nature.

New Data to Support the Suggested Structure of Asparagine

The new concept of the structure of asparagine has also led to notable success in interpreting other observations.

The Behaviour toward Ninhydrin. Under conditions which produce the blue compound, similar to that obtained with glutamine, asparagine reacts with ninhydrin to give the expected liberation of carbon dioxide[20]. But would asparagine yield carbon dioxide under the conditions that lead to the brown colour? If asparagine, unlike glutamine, exists in a cyclic form involving the carboxyl group in the ring, it should not yield carbon dioxide with ninhydrin.

After our views of the structure were formulated, we were able, through the co-operation of Dr. G. Krotkov, of Queen's University, Kingston, Ontario, who had available asparagine containing carbon-14, to prove definitely that no carbon dioxide is evolved when asparagine reacts with ninhydrin to form the brown compound, but that radioactive carbon dioxide is evolved when the blue compound, characteristic of the reaction of glutamine with ninhydrin, is formed.

The asparagine was a product of biological synthesis (by Wilson *et al.*[28]) and contained part of its radioactivity in the 'carboxyl carbon' according to the conventional formula. At our request, Dr. Krotkov performed the following experiments:

(1) Asparagine was allowed to react with ninhydrin on paper in such circumstances (ninhydrin in 95 per cent alcohol and temperature of 60° C.[19]) that the brown product was formed.

(2) Excess asparagine was warmed with ninhydrin in a test tube so that the brown product was formed.

(3) Asparagine was heated[29] with excess ninhydrin forming the blue compound.

The results were striking. Treatment 1 involved no loss in radioactivity, treatment 2 involved no loss in radioactivity, but treatment 3 allowed 55 ± 3 per cent (mean of six determinations) loss in radioactivity.

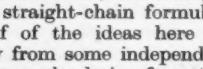
The behaviour of asparagine toward ninhydrin is now intelligible in terms of its cyclic structure. When it reacts brown, as on paper without drastic heating and in 95 per cent alcohol, the compound is reacting in its cyclic form. On heating, as in a test-tube, in aqueous solution after Moore and Stein[29], the ring is opened and the asparagine reacts like glutamine, forms a blue compound, and also loses carbon dioxide. The latter behaviour cannot be explained by hydrolysis to aspartic acid because: (i) asparagine is stable under these conditions[11,12]; (ii) the reactions of asparagine and aspartic acid with ninhydrin are somewhat different[20,30].

It is equally clear that the test also showed that Dr. Krotkov's radioactive asparagine, as synthesized by lupin plants in six days of 16 hr. in the light and 8 hr. in the dark, had 55 per cent of its radioactivity in the carbon to which the amino group is in the alpha position.

Infra-red Absorption Spectra. In a problem of this kind it is obvious that infra-red absorption spectra would be instructive. Such spectra obtained under comparable conditions for both glutamine and asparagine have not been published. However, through the courtesy of Dr. R. C. Gore, of the

American Cyanamid Co., of Stamford, Conn., we obtained access to such unpublished data. These data show that the structures of glutamine and asparagine are different. Glutamine has a pronounced band at 1,420 cm.$^{-1}$ not present in asparagine, and asparagine has a strong absorption band at 1,530 cm.$^{-1}$ not present in glutamine. The band at 1,420 cm.$^{-1}$ is attributed to an ionized carboxyl group, and the band at 1,530 cm.$^{-1}$ could be due to an imide linkage adjacent to an unsaturated group (for example, carbonyl group). These data are consistent with the idea that asparagine has no carboxyl group but has a cyclic imino structure, and that glutamine has the conventional straight-chain formula.

Final proof of the ideas here presented should rightly follow from some independent evidence of a kind which can only derive from the cyclic formula for asparagine contrasted with the straight-chain formulation for glutamine. By methods of X-ray diffraction it should be possible to demonstrate the imide linkage



if it exists in crystalline asparagine. The crystal structure of asparagine has, in fact, been examined by Bernal and contrasted with that of aspartic acid[31]. The crystal pattern for asparagine showed that a straight-chain structure is improbable, for the carboxyl and amide groups are in close proximity; but the data then available were not enough to demonstrate the actual imide linkage which the cyclic formula demands. The X-ray work, however, should clearly be pursued in the hope that an unequivocal conclusion is possible. We are aware that Dr. R. Pepinsky, of Pennsylvania State College, who has already examined the structure of glutamine and concluded that it has the structure compatible with the usual open-chain formula, will now undertake similar work for asparagine.

Evidence from Synthesis. Other attempts (made by J. F. T.) to obtain chemical evidence have been on the following lines:

(1) The attempted synthesis of amino succinimide to test whether this substance is a dehydration product of anhydrous asparagine. It is curious that this substance seems not to have been synthesized; no attempts that we know about to synthesize this compound have given the desired product.

(2) The attempted removal of two molecules of water from asparagine (formula IV) to form amino succinimide. One molecule of water is removed readily (formula III), but further removal of water to give amino succinimide (formula I) is strongly resisted and has not, so far, been possible.

Conclusion

The cumulative evidence, however, is strong and the conclusion is that glutamine and asparagine—two of the most important soluble nitrogen compounds which occur free in Nature—are not true homologues, but, as they exist in solution, they have a different structure. The thesis developed here is that asparagine rather than glutamine has the more anomalous structure which is cyclic. It may seem strange that, although asparagine has been known for nearly 150 years and its homologue glutamine for about 70 years, it is now necessary to question their molecular relationships. The reasons for so doing, however, derive directly from the importance of these substances in metabolism and from the current interest in their role in Nature.

Acceptance of the ideas here expressed would clearly have far-reaching physiological significance.

Acknowledgments

Without implicating others in any of the controversial points to which we have referred, we wish to acknowledge that we have gratefully availed ourselves of the opportunity of discussing this problem from the point of view of biochemistry with Dr. H. B. Vickery, of the Connecticut Agricultural Experiment Station; and with Prof. K. V. Thimann, of Harvard University. The problem was discussed from the point of view of molecular structure with Prof. C. K. Ingold, of University College, London, during his stay on the Cornell Campus as George Fisher Baker non-resident lecturer in chemistry. Dr. M. L. Huggins, of the Eastman Kodak Company, Rochester, New York, also gave us the benefit of his views, and Dr. R. C. Gore, of the American Cyanamid Co., Stamford, Conn., enabled us to evaluate data from infra-red analysis which he furnished. From Dr. R. Pepinsky, of Pennsylvania State College, Penn., we obtained data that support the view that crystalline glutamine hydrochloride has a straight-chain structure. The ready co-operation of Dr. G. Krotkov, of Queen's University, Kingston, Ontario, in the experiments with radioactive asparagine is most gratefully acknowledged.

The very fact that all these authorities have readily appreciated that a problem exists in the interpretation of the structures to be assigned to glutamine and asparagine is further justification for presenting these views, even though they necessarily entail a measure of speculation.

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SYSTEMATIC SHIFTS IN THE ULTRA-VIOLET ABSORPTION SPECTRA OF POLYCYCLIC AROMATIC HYDROCARBONS

FOLLOWING the extensive experimental work of Clar[1], Mayneord and Roe[2], and Jones[3], attention has recently been focused on the more theoretical aspects of the electronic energy-levels and the ultra-violet absorption spectra of polycyclic aromatic hydrocarbons.

Calculations based on the valence bond method, and the scheme of interacting molecular orbitals, have been carried to varying degrees of approximation for the simpler aromatic hydrocarbons[4], but the complexity of the problem when three or more condensed aromatic rings are involved has so far prevented any extensive results from being forthcoming.

It would seem fruitful to consider a more general aspect of the problem, namely, the change in electronic energy-levels among a regular sequence of polycyclic aromatic hydrocarbons. Hitherto, only Baldock[5] has attempted calculations along these lines, considering the polyacene series. Sufficient evidence is available from a consideration of the ultra-violet absorption spectra of these hydrocarbons to suggest this method of approach is worthy of a more intensive investigation.

There are two well-defined series of polycyclic aromatic hydrocarbons: the polyacenes, embracing anthracene, naphthacene, pentacene and hexacene; and the angular or bent systems, phenanthrene, chrysene and picene. The simple hydrocarbons benzene and naphthalene might be considered as precursors of either sequence. In the wave-length region commonly studied, each hydrocarbon exhibits absorption bands arising from three well-defined electronic transitions, predicted on the basis of the free electron model[6], which, however, as yet does not permit of quantitative calculations.

Fig. 1 shows the position of the band of longest wave-length of each transition, measured in cm.$^{-1}$, plotted against reciprocal molecular weight, for the polyacene series. The measurements refer to *iso*-octane or saturated paraffins as solvent, and where data relating to such solvents are not available an appropriate correction has been made, since phenanthrene[7] and other polycyclic aromatic hydrocarbons show distinct wave-length shifts in solvents such as

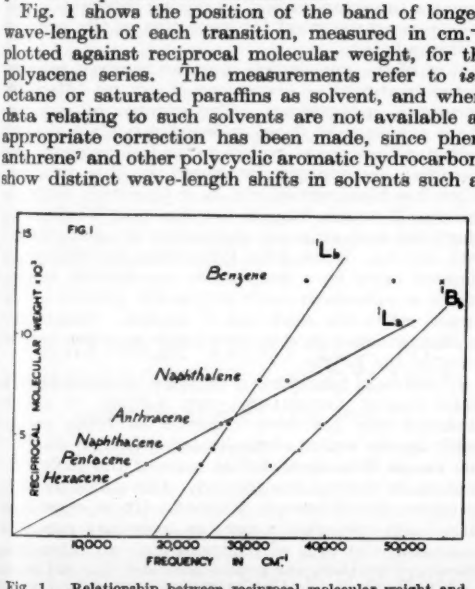

Fig. 1. Relationship between reciprocal molecular weight and frequency for polyacenes

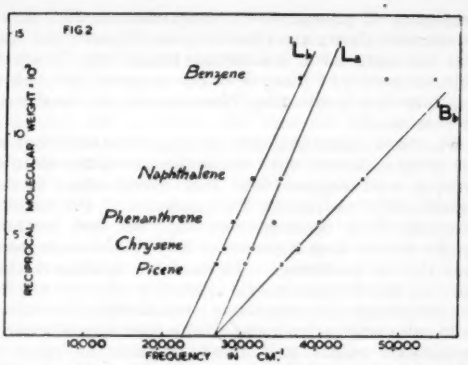

Fig. 2. Relationship between reciprocal molecular weight and frequency for angularly condensed polycyclic aromatic hydrocarbons

chloroform and benzene. Fig. 2 shows a similar plot in the case of the sequence of angularly condensed hydrocarbons. In each figure, the relevant data for both benzene and naphthalene have been added.

In the case of the polyacenes, with anthracene as the member of lowest molecular weight, the ^1L_a transition gives a linear plot, passing through the origin. This indicates that, for an infinitely long polyacene molecule, the excited level would coincide with the ground-state, a result also obtained by Baldock. Qualitatively, this result is also in accord with the free-electron concept, since the long axis of the polyacene series lies in a direction perpendicular to the axis of polarization. The two remaining transitions, ^1L_b and ^1B_b, give linear relationships, which attain the finite values 18,200 cm.$^{-1}$ and 25,000 cm.$^{-1}$, for an infinite molecular weight. The existence of definite series limits is thus apparent.

It has been considered expedient to draw the line through the points for the ^1B_b transition as shown, rather than to obtain a better correlation for the hydrocarbon pentacene. Measurements on the hydrocarbon were made by Clar, using benzene as solvent, and it has been necessary to apply a rather large and uncertain correction for the solvent shift of the ^1B_b maximum. Furthermore, Clar has noted the marked tendency towards peroxidation of solutions of this hydrocarbon. These facts seem to provide sufficient justification for placing greater weight on the data for the polyacenes of lower molecular weight.

The angularly condensed series shows an equally regular behaviour. For the ^1L_b, ^1L_a and ^1B_b transitions, the respective series limits of 22,500 cm.$^{-1}$, 26,600 cm.$^{-1}$ and 26,600 cm.$^{-1}$, are obtained. Thus the ^1L_a- and ^1B_b-levels converge, a fact which is evident from the spectrum of the hydrocarbon picene, where a significant overlap of the relevant bands is beginning to occur. Furthermore, those values demonstrate that no hydrocarbons of this class will be appreciably coloured.

The position of the longest wave-length band of the ^1L_a transition of phenanthrene is anomalous, and a consideration of the circumstances suggests it is not advisable to include this point when drawing the best straight line through the available data. The vibrational bands of the ^1L_a transition of the angular series of hydrocarbons, as exemplified by naphthalene, chrysene and picene, are by no means so clearly resolved from the general background absorption as the corresponding bands of the polyacenes. However, the longest wave-length band of the ^1L_a

transition of phenanthrene, occurring at 2925 A. in *iso*-octane[7], shows a marked degree of resolution, and Clar has assigned to it a distinct transition. The free-electron model of Platt does not suggest that this is so; but this interesting phenomenon is worthy of further study.

The three transitions of the hydrocarbon naphthalene are more in accord with the sequences of the angular system, and suggest that this hydrocarbon is not significantly polyacene in character. On general grounds, it is optimistic to suppose that benzene might be the first member of any of the sequences, and this is confirmed. It may be significant that only in the forbidden ^1L_b transition does it exhibit the behaviour of an angularly condensed hydrocarbon.

An almost exact parallel to the correlation between molecular weight and band position in cm.$^{-1}$ is obtained when the latter entity is related to the number of resonating carbon atoms in the various molecules considered. This must necessarily be so, since a high degree of proportionality exists between the molecular weight and the number of resonating carbon atoms, excepting those aromatic hydrocarbons of low molecular weight.

Since the hydrogen atoms of these molecules play a definite part in determining the precise position of the absorption bands of polynuclear aromatic hydrocarbons, by virtue of the finite polarizability of the σ-type C—H bonds, it has seemed desirable to take them into account. This is most conveniently accomplished by considering the overall molecular weight of the hydrocarbon in question, rather than the number of resonating carbon atoms contained in the structure.

W. F. Maddams

169 Reigate Avenue,
Sutton, Surrey. Dec. 17.

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FOREST PRODUCTS RESEARCH

REPORT FOR 1949

THE latest report of the Forest Products Research Board*, which is for the year 1949, affords a good illustration of the increasing activities of the Forest Products Research Laboratory at Princes Risborough and of the many different forms of research that are now being carried out there. These include problems in connexion with timber or timber utilization in the fields of the botanical sciences (wood structure and physiology), mycology, entomology, chemistry, physics, timber mechanics and seasoning, woodworking and wood preservation. In spite of the extensive research programme, advisory work continues to be an important feature, nearly thirteen thousand inquiries being received annually. These are not confined to the British Isles, and assistance is often given to Commonwealth countries.

* Department of Scientific and Industrial Research. Report of the Forest Products Research Board with the Report of the Director of Forest Products Research for the Year 1949. Pp. 50+8 plates. (London: H.M.S.O., 1951.) 2s. 6d. net.

The testing of British Colonial timbers continues to receive high priority and to engage much of the attention of the specialist sections. These have included timbers now being exploited in Nigeria, the Gold Coast, Uganda, East Africa, British Guiana and Malaya. A pilot plant for investigating the possibility of utilizing tropical timbers for hard-board manufacture has been established.

An interesting problem has been that concerned with the utilization of 'Rhodesian teak' (*Baikiæa plurijuga*) in Northern Rhodesia. Large areas of Rhodesian teak forest destroyed in the past contain a considerable volume of dead standing trees or half-burnt logs (estimated at several million cubic feet). This timber is of a dry, hard and abrasive nature and has been left almost untouched by sawmillers as too troublesome to saw. It was found that this refractory timber could be worked satisfactorily by the use of hard-tipped inserted saw-teeth, that is, teeth tipped with 'Stellite'—a very hard alloy of cobalt, chromium and tungsten. The 'Stellite' tipped teeth gave more than six times the output of ordinary teeth, in some instances as much as ten times, before sharpening was necessary. An improved method of preparing the teeth and depositing the 'Stellite' in the mill was evolved. The cost of 'Stelliting' was counterbalanced by the reduced consumption of teeth. Possibly this process may well prove advantageous with hardwoods in other countries that are found to be severe on saw-mill equipment.

Other sawing studies have been carried out. The stroboscopic method has been successfully employed in studying the action of cutting edges on timber. A technique has been evolved for using either the strobo-torch or high-speed photography for observing the behaviour of sawdust in the tooth gullets of a circular saw. One side of the saw is in contact with a toughened glass window, through which the quantity and path of the sawdust can be either continuously observed or photographed while the saw is in operation at different speeds. This method obviates the errors caused by having to stop the saw and open up the wood for inspection of the sawdust in the gullets.

Most of the mycological inquiries received referred to the treatment or prevention of dry rot (*Merulius lacrymans*) in buildings. The number of inquiries about the cause of decay in wooden boats and ships indicates that naval architects and shipwrights are becoming increasingly interested in this problem. Work has been carried out in co-operation with the Building Research Station, Garston, near Watford, on fungicidal renderings for application to walls infected with dry rot. It has been found that the addition of cuprous oxide to a magnesium oxychloride cement makes it sufficiently toxic to prevent growth of the fungus when the rendering is applied. Paints and renderings based on zinc oxychloride have also proved toxic to the fungus.

It has long been known that the wooden slats in water-cooling towers are very subject to decay. Hitherto this has been regarded as being caused solely by the action of the heated water. A study of the fungal flora showed that none of the recognized destroyers of wood was present. One which destroys cellulose was, however, isolated. It is considered that fungi may play a part as secondary agents in increasing the rate of deterioration—an interesting discovery to both the mycologist and the industrial user. Other mycological studies have been concerned

with the physiology of wood-destroying fungi, sap-stain investigations and laboratory testing of wood preservatives.

In the entomological field the prevalence of pin-holes in tropical hardwoods caused by beetles of the families Platypodidæ and Scolytidæ has attracted much attention. The use of some of the newer insecticides, applied by brush or spray to the logs immediately after felling in order to avoid infestation, is now being employed or tried. Investigations have been continued on *Lyctus* powder-post beetles, the common furniture beetle (*Anobium punctatum*), the death-watch beetle (*Xestobium rufovillosum*), and the house longhorn beetle (*Hylotrupes bajulus*).

Work on the durability of plywood adhesives has been continued in collaboration with the Ministry of Supply, to include tropical tests at Port Harcourt, Nigeria, where plywood can be exposed to conditions ranging from full sun to sheltered storage. Samples of plywood and built-up units were also placed in a 70-ft. torpedo boat for marine tests in H.M.S. *Hornet* at Gosport to investigate the durability of many types of glue. More than five thousand samples have been made for these plywood experiments.

In connexion with timber mechanics, interesting results are recorded in regard to the wearing qualities of some of the newer tropical hardwoods as wood block or strip flooring. 'Muhimbi' (*Cynometra alexandri*) and 'musine' (*Croton megalocarpon*) from East Africa showed promise as substitutes for maple for heavy-duty flooring, especially 'muhimbi'. 'Krabak' (*Anisoptera* spp.) from Siam was satisfactory for light-duty flooring as in domestic and other buildings. 'Kokrodua' (*Afrormosia* sp.) from West Africa was satisfactory as a substitute for Burma teak for ship's decking as regards resistance to wear.

Much of the work in wood bending has been concerned with the bending properties of oversea timbers in the hope that some may be suitable substitutes for the commonly used bending-woods such as beech and ash that are now in short supply. Of twenty-five species tested, none was equal to beech in bending properties. It is understood that some notable advances in wood bending have been made at Princes Risborough since the report was written.

Research on pruning has also fallen within the purview of the Forest Products Laboratory, a senior officer having visited Germany to study the effects of the pruning of conifers on the reduction of knots in the wood. Good reasons exist for pruning Douglas fir, and special quality Scots pine, but on the Continent green pruning of spruce is associated with the admittance of fungal decay.

CARNEGIE TRUST FOR THE UNIVERSITIES OF SCOTLAND

ANNUAL REPORT FOR 1950–51

THE fiftieth annual report of the Carnegie Trust for the Universities of Scotland* covers the academic year 1950–51, completing fifty years work since the trust deed was signed by Mr. Carnegie on June 7, 1901. The main topic discussed in the report is that of assistance given to students towards their class-fee payments, on which the executive committee of the Trust entertains some anxiety. It appears to the committee that the function of the Trust was narrowed considerably by the Education (Scotland) Act of 1946, and that for fee assistance the committee needs to consider only those who were not recipients of education authority bursaries. On this basis, only £7,836 (to 370 students) was paid out in 1950–51; but a further review of the whole situation has led the committee to conclude that, where the amount of the bursary together with other factors, such as the family resources and the cost of living away from home, appear to warrant it, it would be justified, if it so desires, in continuing to give assistance with the class fees to those holding bursaries from the education authorities as well as to those who have no such aid. From the beginning of the academic year 1951–52, the executive committee has modified its regulations accordingly; but no return to the original scale is contemplated in view of the substantial bursaries now awarded by the authorities.

This development will affect the ability of the committee to develop still further its schemes for postgraduate study and research, to which during 1950–51 a record amount of £38,170 was allotted. The first list of recommendations for awards under the new schemes initiated in October 1950 convinced the committee that the lower age-limit should be thirty years and that awards in any one year should be restricted to ten at most. For 1950–51, two awards were made for cancer and dermatological research in the United States; two in geography, one recipient going to the north-east Mediterranean littoral and the other to Cape Breton Island; one in botany at the University of California; two in literature, for study at Yale University and in Germany, respectively; and one for investigation into racial relationships in southern Africa. A maximum of £6,000 is proposed for this aspect of the research scheme. The demands for expensive items of equipment by workers in many fields of science and medicine have caused some embarrassment, and the committee has been compelled to require all individual applications to the Trust of this type to be submitted through the authorities of the university or college from which application is made.

During the first few years of the eighth quinquennial (1947–52), supplements to the extent of £67,000 were made to universities and colleges; but the "Abstract of Grants and Payments in the Accounts" appended to the report shows considerable undrawn balances, totalling £74,940. The University of Glasgow has steadily taken up the grant in assisting in payments for the final portion of the Chemistry Institute. The executive committee notes that the amount of £1,033 repaid by former beneficiaries was the lowest recorded in the past thirty years. Appendixes to the report deal with the work of investigators under the research scheme during the academic year 1950–51, and list publications by fellows, scholars and recipients of grants received since September 30, 1950, as well as papers assisted by a grant of £500, and fellowships, scholarships and grants awarded for the year 1951–52. Statistics of assistance to students during 1950–51, with comparative tables for 1949–50 and 1950–51, are included, as well as details of the modified scheme for the endowment of postgraduate study and research.

* Carnegie Trust for the Universities of Scotland. Fiftieth Annual Report (for the Year 1950–51) submitted by the Executive Committee to the Trustees on 25th February, 1952. Pp. iv+68. (Edinburgh: Carnegie Trust, 1952.)

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

A Radio-Astronomical Investigation of Winds in the Upper Atmosphere

There have been a number of attempts during the past few years to investigate movements in the earth's ionosphere by radio techniques, in which signals, transmitted from the earth, are observed after reflexion in the ionosphere[1]. This communication summarizes results obtained recently by a new method, in which use has been made of the extra-terrestrial radiation from the two most intense radio-stars in the constellations of Cygnus and Cassiopeia.

The radiation received on the earth from the radio stars often fluctuates in intensity, as shown in the pen-recordings reproduced in Fig. 1. It has been found that the occurrence of these fluctuations shows a high degree of correlation with the presence of irregularities in the *F*-region of the ionosphere (sporadic *F*), and it is now generally agreed that they result from the diffraction of the incoming radiation as it passes through these inhomogeneities[2,3]. On a radio-frequency of 80 Mc./s., the duration of individual fluctuations is usually of the order of 0·5 min., and during disturbed conditions the incoming radiation is modulated by about 40 per cent. When observations are carried out with similar receiving equipments spaced over base lines of a few kilometres, it is possible to detect small displacements in the time of occurrence of the individual fluctuations recorded at the various receiving stations. These time displacements are the result of the drift of the diffraction pattern across the ground, and this motion is attributed to the movement of the electron clouds in the *F*-region.

In the present experiments, these movements have been investigated by using three receivers, arranged triangularly at spacings of approximately 4 km., and operating at a frequency of 80 Mc./s. The motion of the diffraction pattern is calculated from a comparison of the records taken at the three receivers, and, after making a vectorial correction for rotation of the earth, the horizontal component of the ionospheric motion can be deduced. The three typical records reproduced in Fig. 1 have been plotted on a common time-scale and show that the time displacements may be readily determined.

The fluctuations, like the sporadic *F* conditions which cause them, are essentially a night-time phenomenon, and most of the observations described here were made between 1800 h. and 0100 h. U.T.

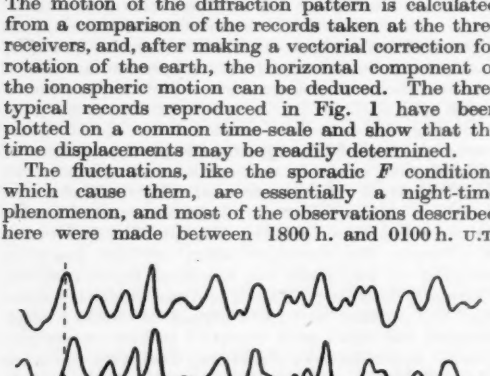
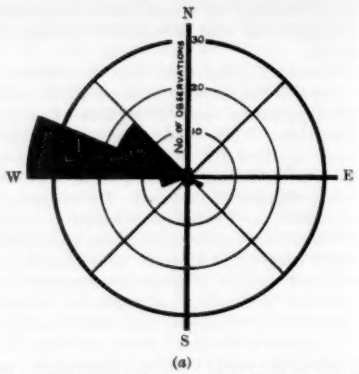
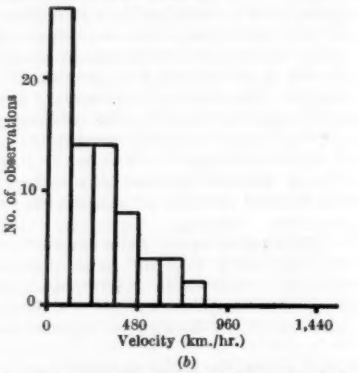


Fig. 1. Fluctuation records obtained simultaneously from three receivers arranged triangularly at spacings of approximately 4 km.



(*a*)

Fig. 2 (*a*). Histogram of *F*-region wind directions during May-June low-angle observations (winds *towards* directions indicated)



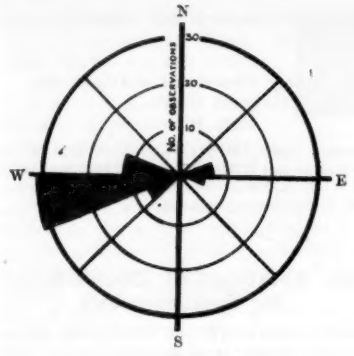
(*b*)

Fig. 2 (*b*). Histogram of *F*-region wind velocities during May-June low-angle observations

Two series of experiments were carried out: (*a*) during May and June 1951 (72 observations on thirteen nights), (*b*) during September and October 1951 (65 observations on fifteen nights). In series (*a*) the radio-stars were at low angles of elevation on the northern horizon, and the results therefore refer to ionospheric conditions at a mean latitude of 60° N., that is, some 800 km. north of the receiving equipments. In series (*b*) the radio-stars were near the zenith, and the results therefore refer to ionospheric conditions at a latitude of 53° N.

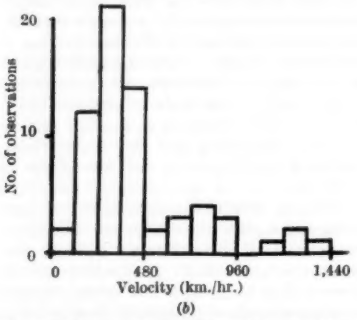
The results show that the *F*-region irregularities have a steady translational movement, and that this is usually maintained in a given direction for many hours. During the periods of observation, the most favoured direction was *towards* the west, the variation in direction over a four-hour observing period being generally less than 25°; the average velocity was approximately 350 km./hr. The full results are summarized in the histograms of Figs. 2 and 3, from which it will be seen that, although the two series of observations gave similar results, the low-angle observations were associated with a significantly lower mean velocity (250 km./hr. compared with 430 km./hr. for the zenith observations). Also, during these low-angle observations, the most favoured direction was some 30° farther towards the north (15° north of west compared with 15° south of west for the zenith observations).

Two further points of interest also emerge from the experimental results. (1) On two occasions, both



(a)

Fig. 3 (a). Histogram of *F*-region wind directions during September–October zenith observations (winds *towards* directions indicated)



(b)

Fig. 3 (b). Histogram of *F*-region wind velocities during September–October zenith observations

near midnight, the wind direction changed by more than 140° within the period of an hour. A number of such 'reversals' were recorded during experiments with two receivers spaced over an 11-km. base-line[2] during February–May 1950, and further cases have recently been reported by Ryle at Cambridge[1]. (2) Although the average duration of individual fluctuations is about 0·5 min., this may range from 0·1 min. on some nights to 5 min. on others. Analysis shows that a linear relationship exists between the rate of fluctuation and the velocity of the diffraction pattern across the ground as determined by the three-receiver observations. This demonstrates that the variation in fluctuation-rate is due to changes in the rate of movement of the *F*-region irregularities and not to alterations in their size.

The above information about *F*-region motions is in good agreement with other estimates which have been made using ionospheric sounding techniques[1].

We wish to thank Prof. A. C. B. Lovell for his help with the experiments, and the Department of Scientific and Industrial Research for financial assistance.

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Feb. 6.

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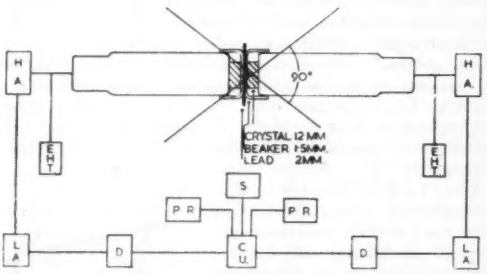
[2] Little, C. G., and Maxwell, A., *Phil. Mag.*, **42**, 267 (1951).
[3] Ryle, M., and Hewish, A., *Mon. Not. Roy. Astro. Soc.*, **110**, 381 (1950).

An Investigation, using Scintillation Counters, of 'Double Stars' due to Cosmic Rays

The number of close pairs of stars formed in 'Nuclear Research' emulsion is greater than expected if the stars are independent and distributed at random[1,2]. It was suggested that a neutral radiation capable of star production was emitted isotropically from all stars. For this hypothesis it was necessary to assume that fourteen penetrating particles were produced per star, and that these particles interacted with nuclei with a geometrical cross-section. It was therefore decided to investigate the time correlation between events producing large pulses of ionization in scintillation crystals, to find if double stars are also produced at greater separations than can be observed by the photographic plate technique.

Two potassium iodide crystals, activated with thallium, of approximate dimensions 3·1 cm. × 3·1 cm. × 1·2 cm. and of weights 35·3 gm. and 38·4 gm., were placed in good optical contact with two multipliers. The experimental arrangement and conventional electronic apparatus used is shown in the diagram. The apparatus was situated about two feet below a thin boarded roof at an altitude of about 100 metres. During the first part of the experiment, the crystals were placed one above the other, and in the second part the multiplier assembly was rotated so that the crystals were side by side.



H.A., head amplifier; E.H.T., extra high tension; L.A., linear amplifier; D., discriminator; P.R., pen recorder; S., scaler; C.U., coincidence unit

Bias settings corresponding to energy losses of 40 MeV. were determined by comparison with pulses produced by 6·0- and 8·8-MeV. α-particles, obtained by contaminating the crystals with thorium B, and extrapolating linearly. Variations of ± 3 volts in the extra high tension voltage means that events liberating 42 MeV. with fluctuations of the order of 10 per cent were detected.

The frequency of events in the crystals is shown in the accompanying table. The accidental coincidence-rate due to the finite resolving-time of the coincidence unit is negligible.

Effective running time	Counting-rate/day Crystal 1	Crystal 2	No. of coincidences	Coincidences per day
Crystals one above the other 63 days	24·1±0·6	26·4±0·6	25	0·4±0·08
Crystals side by side 36 days	29·7±0·9	31·3±0·9	10	0·3±0·08

In order to compare the observed rate of coincidences with the rate of formation of double stars, one star occurring in each crystal, the rate of production of stars in the crystals must be estimated. This calculation, and several which follow, are lengthy and have been reported fully elsewhere[3]. It is found that thirteen stars/day with three or more prongs should be formed in each crystal; but of these only 70 per cent, that is, nine, produce sufficiently large pulses to be recorded. Preliminary results[4] suggest that only about two two-pronged stars should be recorded per day. It is also estimated that 14 ± 5 events per day should be produced by the proton component. We can therefore account for about twenty-five events per day in each crystal, and this is in fair agreement with the observed counting-rates.

On the basis of the supposed double-star effect, the frequency of the simultaneous occurrence of one star in each crystal is calculated as 1·7 per day. If only 70 per cent of the secondary stars are large enough to be recorded, we should still expect about 1·2 coincidences per day, both for crystals placed one above the other and side by side: it is considerably higher than the observed rates of 0·4 and 0·3 per day for the two arrangements.

Coincidence events will also be produced by large air-showers if at least six particles pass through the crystals placed one above the other. One event is expected per fourteen days. Also, stars produced in the top crystal and having a group of shower particles which lose more than 40 MeV. in passing through the lower crystal will record a coincidence. An approximate calculation yields one such event in fifteen days. Coincidence pulses will also be recorded if the top crystal is discharged by a star emitting a proton which passes into the lower crystal, there liberating at least 40 MeV. It is estimated that one such event should be recorded in three days. Thus, excluding the double star effect, $1/14 + 1/15 + 1/3 = 0{\cdot}5$ coincidence pulses should be recorded a day, and this expected frequency of coincidence pulses is of the same order as the observed rate of 0·4 events/day.

It is therefore concluded that the frequency of double stars detected by the crystals must be very much smaller than that estimated from the emulsion results. It is now learned[4], however, that the rate of production of double stars in emulsion is much lower than was originally concluded.

A continuous recording of the arrival of single pulses, which are mainly produced by stars and the proton component, was obtained. Although a slight decrease of frequency of events in each crystal with time was observed, this is considered to be due to a slow drift in the bias setting and not to a slow variation in the intensity of the cosmic rays. There is no evidence of any diurnal variation in this experiment.

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Atomic Energy Research Establishment,
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Nov. 10.

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[2] Leprince-Ringuet and Heidmann, *Nature*, **161**, 844 (1948).
[3] Harding, J. B., A.E.R.E. Report N/R 804 (1952).
[4] Lattimore, S. (private communication).

A Simple Rotating-Cell Double-Beam Unit for Spectrometers

Recording spectrometers employing a.c. radiation beams are generally used in conjunction with amplifiers which are tuned to be selective at the chopping frequency used in the instrument. When absorbing material is placed in the radiation beam, alternate pulses of zero radiation I_0, and of (total radiation minus absorbed radiation) I_A, are sent into the monochromator at a controlled frequency ν_c. If the intensity of the radiation beam passing through the reference or blank cell into the monochromator is I_B, and if the beam is made to alternate between the two cells with the frequency ν_c, the a.c. impulse falling on the detector will be a function of the difference between I_B and I_A and not of the difference between I_0 and I_A. A spectrometer employing such a system will in effect be a double-beam instrument.

By mounting a pair of absorption cells in a suitable holder in front of the entrance slit of the monochromator, it is possible to make the cells rotate at such a speed that the radiation beam passes into the monochromator with a chopping frequency equal to ν_c. In this type of double-beam system, it is essential that the radiation losses caused by scattering and reflexion are made equal for the two cells. In the

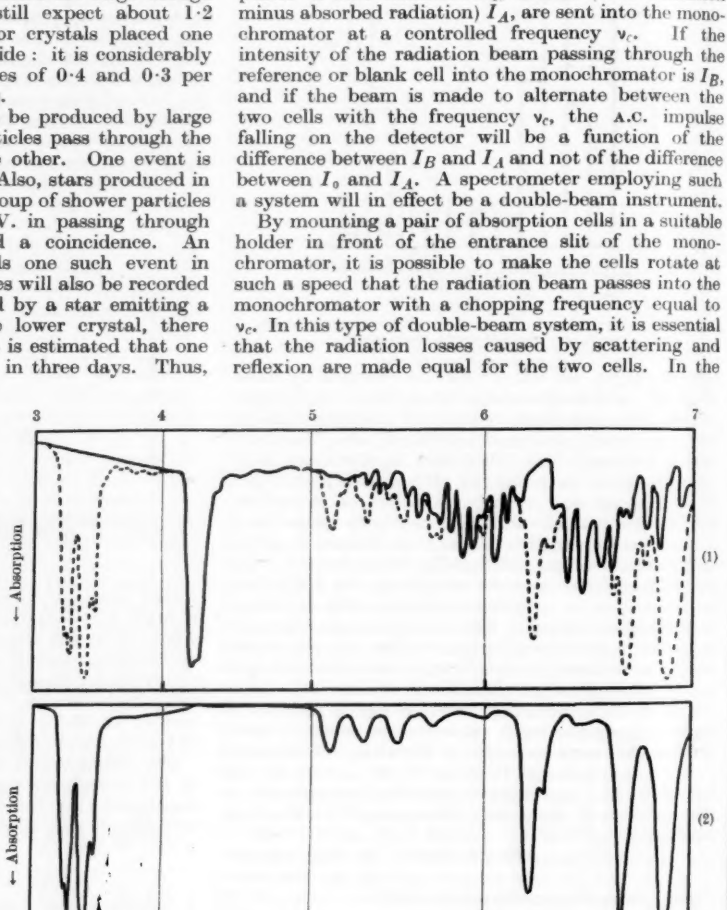

Fig. 1. Full line, radiation curve; broken line, polystyrene spectrum
Fig. 2. Polystyrene spectrum

unit described here, this loss is balanced by fixing a small adjustable shutter on to the cell which reflects and scatters the least amount of radiation.

Preliminary experiments have been carried out using a single-beam Grubb Parsons *S*.3 infra-red spectrometer. This instrument employs a chopping frequency of $16\frac{2}{3}$ c./s., and the sample and blank cells were rotated in the normal cell-holder at a speed of 500 r./m., the cell-holder being dynamically balanced by suitable counter-weights. (Since the radiation beam passed twice through each cell during one revolution, a speed of 500 r./m. or $8\frac{1}{3}$ r./s. produced a chopping frequency of $16\frac{2}{3}$ r./s.) A governor-controlled A.C. gramophone motor was suitably geared to drive the cell-turret and, by accurate adjustment of the motor speed, it was possible to produce a beam alternation frequency equal to that of the band-pass maximum of the amplifier.

Fig. 1 shows part of the absorption spectrum of a sheet of polystyrene (0·03 mm. thick) when examined by the single-beam method. Fig. 2 shows the absorption spectrum of the same material when examined by means of the rotating-cell unit. In order to demonstrate the removal of absorption due to atmospheric carbon dioxide and water, the instrument case was not dried out during the examination of these spectra.

During the examination of the polystyrene spectrum obtained by both methods, the spectrometer slits were opened continuously by means of a small synchronous motor unit. A device is at present under construction which will enable the *S*.3 spectrometer to produce a record directly on a linear wave-length scale. By means of this device and a slit-drive mechanism similar to that described by Cannon[1], it is hoped to be able to record absorption spectra directly from a spectrometer fitted with the rotating-cell unit.

It should be pointed out that, although this double-beam unit may not prove to be as efficient as some of those discussed by Oetjen and Roess[2], the rotating-cell unit is very simply constructed and requires no extra optical components.

Full details of this double-beam system will be published elsewhere at a later date.

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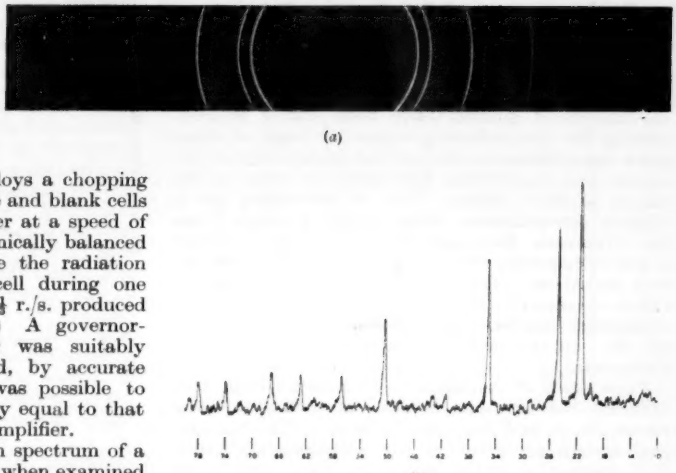
X-Ray Diffraction Pattern of Ammonium Fluoferrate

In the course of an investigation of the adsorption of phosphate ion from solution by sesquioxides, X-ray diffraction methods were used in the identification of ammonium fluoferrate, $(NH_4)_3FeF_6$. Although it has been established[1] that the compound consists of isotropic crystals with a lattice constant a_0 of 9·10 A., a table of *d* spacings has apparently not been published.



(*a*)

(*b*)

X-Ray diffraction patterns of ammonium fluoferrate. (*a*) Powder camera. (*b*) Spectrometer

A sample of ammonium fluoferrate was prepared and its composition verified by chemical analysis. X-ray diffraction patterns were obtained using both powder camera and spectrometer. A Philips Norelco X-ray diffraction apparatus was used with iron radiation (λ = 1·932 A.) and manganese filter. These patterns are reproduced herewith, and the *d* spacings and line intensities obtained from them are given in the accompanying table. The complete list of

X-Ray Diffraction Data for Ammonium Fluoferrate

d (in A.) (exp.)	I/I_0	*hkl*	*d* (in A.) (calc.)	*d* (in A.) (exp.)	I/I_0	*hkl*	*d* (in A.) (calc.)
5·28	100	111	5·25	1·39	10	533	1·39
4·57	61	200	4·55	1·37	5	622	1·37
3·23	45	220	3·22	1·31	5	444	1·31
2·75	6	311	2·74	1·27	10	711	1·27
2·64	8	222	2·63	1·26	5	640	1·26
2·28	29	400	2·28	1·22	15	642	1·22
2·04	11	420	2·04	1·18	5	731, 553	1·18
1·86	16	422	1·86	1·10	5	820, 644	1·10
1·75	14	333, 511	1·75	1·07	10	822, 660	1·07
1·61	9	440	1·61	1·05	5	751, 555	1·05
1·54	9	531	1·54	1·02	5	840	1·02
1·52	6	600, 442	1·52	0·998	10	753	0·999
1·44	5	620	1·44				

d spacings are from the powder patterns (average of five values), which checked well with the spectrometer recordings. The I/I_0 values were obtained from the spectrometer pattern for the lines down to and including *d* spacings of 1·44 A. For *d* spacings less than 1·44 A. the intensities were estimated from the camera patterns. Using the *d* spacings shown and Pauling's a_0 value of 9·10 A., *hkl* values were calculated for each line, and are shown in the table. Theoretical *d* spacings were calculated from these *hkl* figures and a_0 = 9·10 A., and are included for comparison with experimental results.

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Environment and Respiratory Control in Certain Crustacea

The effects of changes in the oxygen or carbon dioxide pressure of the environment on the respiratory movements of animals have been widely studied. Among the invertebrates, either or both of these gases may influence the rate of respiratory movements; but considerable differences are found in the extent of their effects. This is particularly so in aquatic invertebrates; thus, within a single class, the Crustacea, Fox and Johnson[1], and Johnson[2] found considerable diversity in the control of respiratory movements. The work described here was undertaken to estimate the extent to which the degree of respiratory regulation is correlated with the nature of the environment in certain closely related Crustacea.

Four pairs of Crustacea were selected from four different habitats, one member of each pair being an amphipod and the other an isopod. The habitats and species are given in the accompanying table. For observation in the laboratory, each species was given a suitable substratum, and the mean rates of pleopod beat (that is, respiratory movements) of ten resting animals were found for various oxygen pressures, at 14° C.; the semi-terrestrial and marine species were studied in sea water, the brackish species in 50 per cent sea water and the freshwater species in tap water. So far as possible the same ten animals were used throughout.

The relation between rate of pleopod beat and dissolved oxygen content of the water is shown in Fig. 1 for amphipods and Fig. 2 for isopods. The similarity between the two sets of curves is striking: the two semi-terrestrial Crustacea show no regulatory increase in rate of pleopod beat at declining oxygen pressures, whereas all the aquatic species do so, although to different extents. The degree of respiratory regulation can be judged by the steepness of the slope of the curve as the oxygen content of the water declines, or, expressed numerically, by the difference between the rate of pleopod beat in fully aerated water and the highest rate attained. The results given in the table show clearly that the brackish and freshwater Crustacea have a much greater capacity for respiratory regulation than their marine relatives.

Although no actual determinations of oxygen concentration of the various environments were made (since such data, unless obtained at frequent representative times throughout the diurnal and seasonal cycles of the habitat, are usually more confusing than informative), the animals in the algal-choked, shallow and hot brackish lagoon must

Fig. 1

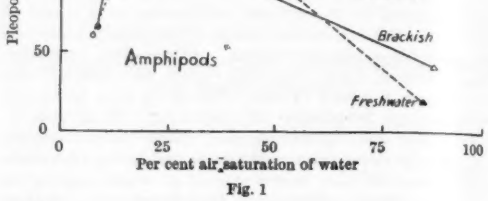

Fig. 2

experience great fluctuations in available oxygen. Similarly, the freshwater Crustacea studied must have been subject to appreciable changes in oxygen concentration[3] in contrast to the shallow-water marine forms in their more constant environment. Finally, the terrestrial species contrast with all the aquatic forms by living in the constant, and, from a respiratory point of view, favourable, medium of air. Thus the degree of regulation of respiratory movements can be correlated with the amount of fluctuation of oxygen in the natural environment. Future experiments should show whether these regulatory differences are genetically controlled, or are, like the metabolic rates of trout fry[4], directly imposed by the environment.

Habitat		Semi-terrestrial Above high water on sea shore, Mediterranean	Marine Among algæ in shallow water, Mediterranean	Brackish Shallow lagoon, Etang de Canet, S. France	Freshwater Artificial pond, Paris
Species (*A*: amphipod; *I*: isopod)	*A* *I*	*Orchestia gammarella* *Ligia italica*	*Melita palmata* *Cymodoce emarginata**	*Gammarus locusta* *Idotea baxteri*	*Gammarus pulex* *Asellus aquaticus*
Rate of pleopods in well-aerated water (beats/min.)	*A* *I*	168·2 119·5	63·4 84·6	28·0 38·8	12·4 18·1
Highest rate of pleopods (beats/min.)	*A* *I*	169·4 120·2	140·9 160·0	182·6 198·8	140·1 166·8
Increase in pleopod rate	*A* *I*	1·2 0·7	77·5 75·4	154·6 160·0	127·7 148·7

* Kindly determined by Dr. Isabella Gordon, of the British Museum (Natural History).

An ecological interpretation of the rates of pleopod beat in well-aerated water is not so obvious. Fox and Simmonds[5] found the oxygen consumption of the freshwater *Gammarus pulex* to be higher than that of the marine *G. locusta* or *G. marinus*, and similarly that of the freshwater *Asellus aquaticus* to be higher than in the marine *Idotea neglecta*, while Löwenstein[6] found the oxygen intake of the brackish *Gammarus chevreuxi* to lie between that of *G. pulex* and *G. marinus*. As regards rate of pleopod beat, however, I find the order to be reversed; the freshwater species, with the highest metabolism, have the lowest rates of pleopod beat, and the marine species, with the lowest metabolism, have the highest rates. For both amphipods and isopods, the marine species moves its pleopods at twice the rate of the brackish species, which similarly has a rate of movement twice that of the freshwater species. The explanation of these differences should perhaps be sought in differences in other aspects of the respiratory physiology of the animals rather than in differences of the environment.

These results will be published in detail elsewhere.

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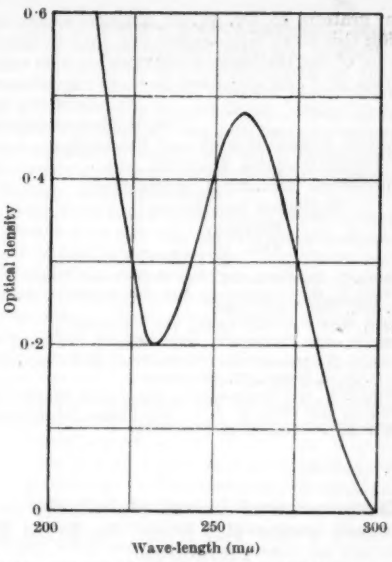
Nucleic Acids in Erythrocytic Stages of a Malaria Parasite

ACTIVE metabolism of nucleic acids appears to be closely associated with the process of protein synthesis; this association is seen particularly in rapidly growing and multiplying cells[1]. It would be expected, then, that the rapid growth of *Plasmodium berghei* in red cells of the mouse would involve the active metabolism of nucleic acids. This organism, therefore, is being used for the study of nucleic acid metabolism and protein synthesis, both by conventional biochemical methods and by ultra-violet spectrophotometry[2]. The amount and nature of the nucleic acids found in the erythrocytic stages of the parasites, as outlined in this communication, has been determined as a preliminary to the examination of erythrocytes infected with different stages of the parasite, and of the action of mitotic inhibitors on the nucleic acid metabolism and protein synthesis of the parasites.

P. berghei was maintained in white mice by intraperitoneal injection with infected blood; after seven to nine days, blood was obtained by cutting the jugular vein. At this time, some 30–40 per cent of the red blood cells were infected, the total red-cell count had decreased and white cells had increased. As the complete separation of parasitized cells from the rest of the blood could not be effected without a considerable loss of material, it was decided to estimate nucleic acids in the solid residue obtained after the hæmolysis of infected blood. This residue contained parasites, white blood cells and red-cell ghosts. In order to correct for the nucleic acids in non-parasite material, it was necessary to estimate the amounts in red-cell ghosts and white cells, isolated from normal blood. It was found that the nucleic acids of the blood residue, estimated by a slight modification of Schneider's method[3], increased with the degree of parasitæmia. In blood with 25 per cent of the red blood cells infected, the content of ribose nucleic acid was 20–25 times greater, and that of deoxyribose nucleic acid was 8–10 times greater than that of the solid residue from normal blood. The average ribose nucleic acid found per parasite was $1{\cdot}16 \times 10^{-7}$ μgm., the average deoxyribose nucleic acid $0{\cdot}59 \times 10^{-7}$ μgm. This may be compared with the content of a single beef-liver cell nucleus: $0{\cdot}3 \times 10^{-6}$ μgm. ribose nucleic acid and $6{\cdot}4 \times 10^{-6}$ μgm. deoxyribose nucleic acid[4], or with a single fowl erythrocyte nucleus, $0{\cdot}09 \times 10^{-6}$ μgm., and $2{\cdot}62 \times 10^{-6}$ μgm. respectively[5]. As in the nuclei of *Paramecium caudatum*[6], the ribose nucleic acid content of *P. berghei* is greater than the deoxyribose nucleic acid content.



Absorption spectrum of nucleic acid extracted from *P. berghei*

The qualitative examination of the nucleic acid of *P. berghei* was carried out with parasites which had been freed from the host's white cells and red-cell ghosts by differential centrifugation. The nucleic acids were extracted from the parasites and purified by the method of Davidson and Waymouth[7]. The absorption spectrum of this material, which is shown in the accompanying graph, corresponded with that of purified ribose nucleic acid and deoxyribose nucleic acid. The purine and pyrimidine content of the nucleic acids from the parasites was determined by the extraction and hydrolysis procedure of Marshak and Vogel[8] and by the chromatographic method of Wyatt[9]. Guanine, adenine, cytosine, uracil and thymine have been detected, but, so far, 5-methyl cytosine has not been found.

This investigation has shown that the erythrocytic stages of *P. berghei* contain the nucleic acids typical of other organisms; the ribose nucleic acid content was about twice the deoxyribose nucleic acid content.

I am grateful to Dr. W. P. Rogers, under whose direction this work was carried out, and to Dr. L. G. Goodwin, of the Wellcome Laboratories, who supplied the strain of *P. berghei* used in these experiments.

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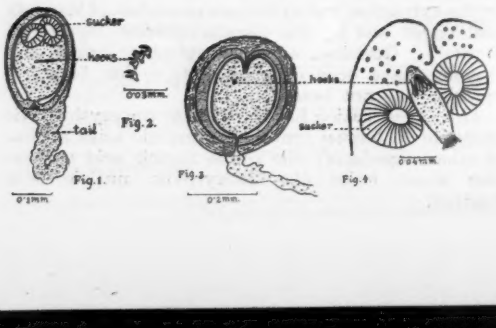
Occurrence of Larval Helminths in *Gammarus pulex* (L.) from the Braid Burn, Edinburgh

In the course of investigations on larval helminths while working in the University of Edinburgh, I found that *Gammarus pulex* (L.), which occurred abundantly throughout the year in the Braid Burn, near the Department of Zoology, harboured larval helminths of five different kinds—two species of Acanthocephala, *Polymorphus minutus* (Goeze) and *Echinorhynchus truttæ* Schrank, two species of cysticercoids new to science, and one form of plagiorchid metacercaria. So far as I am aware, this is the first record of a larval cestode infection in *Gammarus pulex* (L.) in Great Britain.

The two forms of cysticercoids occurred separately and were found attached to the connective tissue of the outer wall of the intestine of the amphipod. One of these, named *Cysticercoid braidburni* n.sp. (Figs. 1 and 2), bears on its rostellum 55–59 bifid hooks which measure approximately 0·01 mm. long. The cysts are oval to elliptical and measure 0·23–0·28 mm. × 0·16–0·175 mm. The four rostellar suckers are devoid of spines. This cysticercoid is closely allied to *Cysticercus integrus* Hamann, 1890, but differs from it in possessing a body half the size, and in having much smaller and fewer hooks of different shape. The other cysticercoid obtained from *Gammarus pulex* (L.), which is named *Cysticercoid gammari* n.sp. (Figs. 3 and 4), has on its rostellum only 10 hooks measuring 0·025–0·027 mm. × 0·0038 mm., and its four rostellar suckers are also devoid of spines. The cysts are almost spherical, 0·31 mm. × 0·33 mm. in size. Of the known ten hooked cysticercoids, the present form comes nearest, in general characters, to *Cysticercus echinocotyle* and *Cysticercus* '*B*' Harper, from both of which it differs, apart from other characters, in lacking spines on its suckers, and to *Cysticercus tenuirostris*, *Cysticercus mirabilis* and *Cysticercus fimbriariæ*, from each of which it differs, besides other characters, in having hooks of different size and shape.



I take this opportunity to thank Prof. James Ritchie, of the University of Edinburgh, who afforded me facilities for carrying out this investigation in the Department of Zoology there.

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Staurophora mertensii Brandt in the Firth of Clyde

It may be of interest to record the occurrence of considerable numbers of the arctic Leptomedusan, *Staurophora mertensii* Brandt[1], in the Firth of Clyde during the summer of 1951. Only two specimens have actually been examined; but reports were received on several occasions of medusæ described as having cruciform gonads of dark brown or black colour and 5–6 cm. in diameter when first seen at the end of May, increasing later to more than 15 cm. Since no other medusa with cruciform gonads exceeds about 5 cm. in diameter, there can be little doubt that these medusæ were *Staurophora*. From these reports it appears to have been common in the water around Bute and the Cumbraes from May to July; but it may have been more widely distributed, since one of the specimens examined was taken on May 30 ten miles south of Ailsa Craig, that is, nearly forty-five miles south of Millport.

In the Atlantic, *Staurophora* is found off the American coast north of Cape Cod and the coasts of Greenland, in the waters around Iceland and the Faroes, and off the Norwegian coast north of Bergen[1]. It is found occasionally around the Shetlands and, although sporadic irruptions into the northern North Sea have been recorded[1–3], this is believed to be the first time that it has been reported on the west coast of Scotland. *Staurophora* does not normally occur in the warm water west of the Hebrides, and in 1951 the only records obtained by the Scottish fisheries research vessels were from west of the Faroes in August and late September[4].

It is difficult to account for this exceptional occurrence of *Staurophora*; the nearest known endemic population, that around the Faroes, is about 400 miles to the north, and the Firth of Clyde is open only to the south-west. It is possible, however, that the medusæ seen in 1951 were released by hydroids which had been brought into the Firth of Clyde from either arctic or Canadian waters as fouling on the bottom of a ship.

I should like to thank Mr. F. S. Russell for confirming my identification of the medusa, and Dr. J. H. Fraser for supplying information about its distribution in the Faroe and Shetland areas.

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Inhibited Development of *Dictyocaulus* Larvæ in the Lungs of Cattle and Sheep

THE limitation to the value of the diagnostic procedure of examining bovine fæces for the larvæ of *Dictyocaulus viviparus* has become increasingly clear during recent years. It has always been realized that immature worms would not reveal their presence in this way, and more recently the effect of host resistance has been recognized in reducing the rate of egg production by the female worms. A third source of error in attempting to diagnose parasitic bronchitis in cattle by fæcal examinations has now come to our notice, in that we have found *Dictyocaulus* larvæ invading the lungs of a partially resistant host, to be retarded in their development for some weeks and in some instances for months, and to constitute a possible source of disease that could not be detected by ordinary means even on post-mortem examination.

Having observed the presence of undeveloped *Dictyocaulus filaria* in the lungs of resistant experimental sheep a hundred days after the administration of infective larvæ, we proceeded to look for the same thing in naturally occurring cases of parasitic bronchitis in adult cattle and, using Baermann's apparatus, we were able to show the presence of minute worms in the lungs of animals that had been showing disease symptoms for some weeks. In one of these cases, the animal had been away from a source of infection for the previous eight weeks. In subsequent experimental infestations in cattle, we have recovered immature worms at post-mortem examination 20 days, 41 days, 56 days and 80 days after the administration of the infective larvæ.

These microscopical worms are in the earliest fifth stage of development, ranging down to 0·58 mm. in length; the largest number that we have recovered in any one instance was 451. On account of the crudeness of the method, however, it seems likely that the actual numbers present were greatly in excess of what we recovered. In most instances, larger worms are also found and sometimes worms of every size throughout the whole range of the fifth stage up to the egg-laying adult.

Helminthologically, the observation is of interest as being an addition to the recorded instances of inhibition of development and extended prepatent period during the parasitic life of nematode worms.

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Fusarium Wilt of Guava (*Psidium guyava* L.) in Uttar Pradesh, India

GUAVA is grown extensively in Uttar Pradesh and is a major fruit crop of the State, occupying nearly 70,000 acres of land. A wilt disease was first reported from the Allahabad district of the State[1]. This district is noted for its fine quality guavas and supplies a very large number of grafted plants from its nurseries to the rest of the country. The disease has advanced with great rapidity within a few years and has become a menace to successful cultivation of this valuable fruit in the eastern districts of the State. A rough estimate puts the area threatened by this disease at about 20,000 square miles.

The symptoms of the disease have been accurately described by Das Gupta and Rai[2] and Vestal[3]. There has been some difference of opinion about the cause of the disease. The former consider the disease to be caused by *Fusarium* sp., while the latter attributes it to *Cephalosporium* sp. In both cases there has been no determination of the species of the causal organism. The present work was undertaken to establish the real identity of the pathogen.

On close examination of freshly wilted plants, we could always find that the surface growth showed the presence of *Cephalosporium* sp. Very large numbers of isolations from the wilted plants were carried out, and a wide variety of fungi was obtained. The principal among these were *Fusarium* and *Cephalosporium*; the latter was distinguished from the former by complete absence of macro-conidia. Besides this major difference, the isolates varied among themselves in the production of pigments, presence and absence of sporodochia and pionnotes and the type of aerial mycelium.

All the isolates so obtained were invariably single-spored, according to the methods of Hansen and Smith[4]. Pathogenicity trials showed that both caused wilting. While producing single spores from pionnotal type, we found that occasionally we got strains which do not form macro-conidia. This type of phenomenon has already been discussed by Snyder and Hansen[5] and Prasad[6]. We consider that strains showing the characters of *Fusarium* and *Cephalosporium* belong to one and the same fungus; but in the case of certain strains the capacity to produce macro-conidia is lost, or we do not know the true conditions under which such strains form macro-conidia.

The characters of the strain showing macro-conidia are as follows: sporodochia and pionnotes present, macro-conidia present, mostly 3–4-septate, sickle shaped. Measurements of conidia are: 0-septate, 7–10 μ × 2–3 μ; 1-septate, 15–20 μ × 3–4 μ; 3-septate, 32–40 μ × 3–6 μ; and 4-septate, 37–50 μ × 4–7 μ. Chlamydospores present, both intercalary and terminal.

These characters place the organism under section Elegans of Wollenweber and Reinking's system of classification[7]. Snyder and Hansen[5] have shown the unreliability of the characters separating the species in this section, and have reduced the entire section to one species, namely, *Fusarium oxysporum* Schl. emend. Snyd. et Hans. We accept Snyder and Hansen's concept of species in the genus *Fusarium*, and propose to name the guava wilt pathogen *Fusarium oxysporum* f. *psidii*.

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Occurrence of the Terrestrial Alga, *Fritschiella tuberosa*, Iyengar, in Africa

The terrestrial Chætophoraceous alga, *Fritschiella tuberosa*, which was first discovered[1] by Prof. M. O. P. Iyengar in India from soil in drying rain-pools in Madras and Mysore, and later recorded from Fyzabad[2] and the Benares district[3], has now been found at Khartoum, in the Anglo-Egyptian Sudan. It occurs there during August, September and October in drying silt on the banks of the Blue Nile as the river recedes after the summer floods. It has been found in this situation for three years in succession with the alga *Protosiphon botryoides* (Kutz.), Klebs., var. *deserti*, Nayal, and grows in such profusion that the bare silt assumes a distinctly green coloration.

The Khartoum plants, though in general agreeing well with the descriptions of Iyengar and Singh, differ, however, in the poor development of the secondary projecting system. Observations in the field and under laboratory conditions suggest that this is due to the very dry atmospheric conditions and high temperatures occurring in Khartoum.

It is proposed to publish elsewhere a more detailed account of observations relating to the occurrence of *Fritschiella* in Khartoum.

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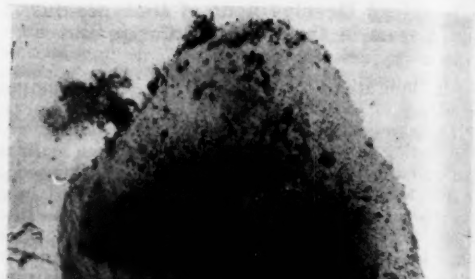

Fig. 1

Possible Protozoan Remains in Permian Salt

Some years ago, Dr. G. M. Lees asked me to examine some 4-in. cores of Permian rock salt from the Eskdale bore hole, N. Yorkshire, of which the stratigraphy has been described[1]. The specimens were mainly from the Middle Saline Group, 3,900–4,200 ft. The cores had been kept in sealed glass jars and were in good condition for examination. The salt of this zone is mainly stained red or pink by disseminated fine hæmatite, and these iron-rich salts contain the bodies here mentioned, of which a fuller account will be published elsewhere.

On breaking the cores to obtain fresh uncontaminated material, washing and afterwards immersing small fragments in distilled water and observing the process of solution under a × 50 binocular, a number of interesting features may be observed.

Occluded gas begins to be released immediately in minute bubbles and, as solution progresses, red filamentous material may be released in longish masses bound together sometimes by a mesh of fine siliceous threads embedded in a mucilaginous mass. Individual masses or colonies may be up to 2 or 3 mm. long, and in them are occasionally found reddish globular or lobed cyst-like sacs which can be freed from the matrix (Fig. 1). These may be transparent when wet; but, after washing with distilled water and dehydrating with acetone, they are seen to be collapsed membranous sacs. These 'cysts' (0·2 mm.–1 mm. in diameter) may be clear, honey-yellow or red-brown with areas of deeper colouring, but no definite structural detail is visible under ordinary light and no stains have yet been found to react with them. A few circular areas have been noted but are inconclusive as vacuoles. Some specimens exhibit a few straight spicules within or protruding from the periphery. The sacs are permeable.

Distinct from the above are pieces of broken membrane composed of a yellowish to transparent mucilaginous matrix in which is embedded a dense mesh of fine silica (?) threads up to several millimetres long. The threads of filaments or spicules may be straight, curved or closely coiled, usually

Fig. 2

one or other type predominating in a specimen, though both may be present. In the cyst-like forms these have not been observed well developed (Fig. 2).

The spiculæ show tapering, but so gradually that careful observation with a 1/12-in. immersion objective is necessary to detect it. Neither anastomosis nor branching has been proved.

The suggestion is that these bodies represent protozoan forms which lived in the iron-rich waters of the Permian sea and have been almost perfectly preserved in the rock salt. Their form suggests affinities with the Heliozoa.

Associated with these forms are various fine fibres, probably of plants; but a further description must be postponed owing to the difficulties of ensuring freedom from atmospheric dust particles.

Preliminary examination of the red anhydrites from Eskdale suggests that some of the red staining is associated with bodies similar to those described.

Collection is conveniently carried out by dissolving a few grams of washed and clean salt in distilled water in a clean bottle with a ground-glass stopper. Many of the forms ultimately float at the top of the saturated brine layer supported by air bubbles and may be removed singly by a capillary tube and mounted either directly in glycerine jelly or, after clearing of brine and washing with acetone, mounted in Canada balsam.

Occasionally fragments of the larger spicular membranes have been recovered from the dried rock cuttings obtained in the course of drilling. These have the appearance of investments, broken and removed from a central cyst.

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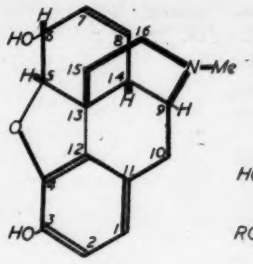
[1] Lees, G. M., and Taitt, A. H., *Quart. J. Geol. Soc.*, **101** (1946).

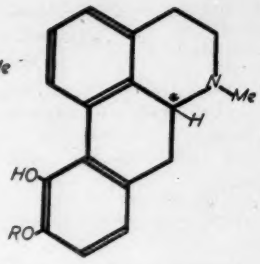
Absolute Stereochemical Configuration of Morphine

The morphine molecule contains five asymmetric carbon atoms and five interlocking ring systems, and constitutes a complicated three-dimensional structure the stereochemistry of which has recently attracted considerable interest. The initial suggestions of Schöpf[1] concerning the relative orientations at the asymmetric carbons 5, 9, 13 and 14 were extended by Fieser and Fieser[2] to include carbon 6, and in terms of these deductions morphine has structure I or its mirror image. Further evidence leading independently to the same conclusion has been found[3] by Dr. H. L. Holmes of the Riker Institute, Los Angeles, and confirmation of the relative configurations shown at carbons 5, 6, 9 and 13 has been provided by Rapoport and Payne[4]. However, up to the present, it has not been possible to decide whether structure I represents morphine or its enantiomorph.

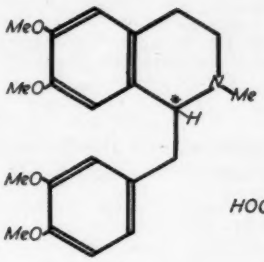
Morphine can readily be transformed into apomorphine (II; $R = H$), which retains only one asymmetric centre (marked *) present in morphine, and if the orientation at this centre could be found



(I)



(II)



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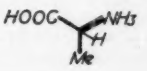

(IV)

in terms of a simple standard, the configuration of morphine could be deduced at least in terms of the conventional model substances. One method whereby the stereochemistry of apomorphine might be related to that of a simpler compound structurally similar to it is by a study of the displacements in rotation of the two substances in a series of solvents of different polarities. This method has been used in the amino-acid field[5], and has been applied to alkaloids of the *bis*benzyl*iso*quinoline group by Leithe[6,7], who showed that natural (+)laudanosine could be related through a series of model compounds to (−)α-phenylethylamine, the configuration of which is known since it can be converted by a series of reactions into L(+)alanine (IV). (−)α-Phenylethylamine and (+)laudanosine therefore belong to the L series, and the latter may be represented by (III).

It was considered that L(+)laudanosine is sufficiently closely related in structure to apomorphine and apocodeine (II; $R = CH_3$) to serve as a reference compound, and the rotations of the latter substance in a series of solvents were compared with those given by Leithe[6] for L(+)laudanosine in the same solvents. These results, which will be reported elsewhere, show in each case a progressive increase in algebraic value of the specific rotation with increasing polarity of the solvent. Thus it appears that (−)apomorphine and (−)apocodeine also belong to the L series and have the same configuration at their asymmetric centres as L(+)laudanosine (III). Since the asymmetric carbon in apomorphine corresponds to carbon 9 in morphine, the configuration of the latter centre is correctly shown in structure I, which therefore represents morphine in terms of the conventional reference compounds.

It has recently been shown by Bijvoet *et al.*[8] by an X-ray method which does not involve uncertainties of the type inherent in previous methods that the conventional structure assigned to L(+)tartaric acid is actually the correct one. In terms of this result, all other conventionally assigned structures

which can be related to L(+)tartaric acid are correct, and (I) represents the absolute stereochemical structure of morphine.

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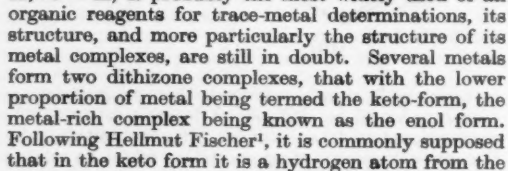
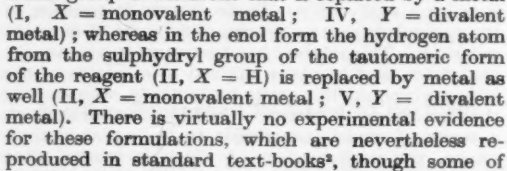
S-Methyl Dithizone and the Structure of Metal Dithizonates

Although diphenylthiocarbazone ('dithizone', I or II, X = H) is probably the most widely used of all organic reagents for trace-metal determinations, its structure, and more particularly the structure of its metal complexes, are still in doubt. Several metals form two dithizone complexes, that with the lower proportion of metal being termed the keto-form, the metal-rich complex being known as the enol form. Following Hellmut Fischer[1], it is commonly supposed that in the keto form it is a hydrogen atom from the imido group of dithizone that is replaced by a metal (I, X = monovalent metal; IV, Y = divalent metal); whereas in the enol form the hydrogen atom from the sulphydryl group of the tautomeric form of the reagent (II, X = H) is replaced by metal as well (II, X = monovalent metal; V, Y = divalent metal). There is virtually no experimental evidence for these formulations, which are nevertheless reproduced in standard text-books[2], though some of them are impossible on steric grounds alone.



(I) (II) (III)



(IV) (V)

Treatment of a chloroform solution of 'keto' silver dithizonate with methyl iodide has now been found to give a monomethyl derivative of dithizone as an almost black solid with a bronze reflex, melting point 118–120°. Now, since it is a monobasic acid[3,4], dithizone dissolves in aqueous alkali, and the action of dimethyl sulphate upon such a solution gives the same methyl derivative. That the methyl group is attached to sulphur and not to nitrogen is proved by the synthesis of the same methyl-dithizone by the action of sodium methyl mercaptide upon an alcoholic solution of ω-chlorodiphenylformazan (III, Z = Cl), itself prepared by coupling chloromalonic acid with benzenediazonium chloride in acid solution. In each case the ω-methylmercaptodiphenylformazan (III, $Z = CH_3.S$—) was purified chromatographically on activated alumina, and the identity of the substances prepared by the three different routes was established by analyses, mixed melting points and by their giving identical absorption spectra in carbon tetrachloride. It is noteworthy that, when a solution in an organic solvent is exposed to sunlight, the absorption spectrum changes in a manner similar to that previously observed in the case of other ω-substituted formazans[5].

As expected from its structure, ω-methylmercaptodiphenylformazan is insoluble in aqueous alkalis and does not give rise to metal complexes under the conditions where metal dithizonates are readily formed. Thus, it must be the thiol group which confers acidic properties upon dithizone[3,4], and it appears probable that it is the hydrogen of this thiol group which is replaced by a metal atom in the formation of a metal 'keto' dithizonate. Further experiments are now in progress in order to elucidate the structure of the enol complexes and towards the synthesis of an N-methyl dithizone (I, $X = CH_3$), which in its thiol form should show acidic properties and be able to form metal complexes, although the internal hydrogen-bonding which probably occurs in dithizone and other derivatives of diphenylformazan[3,5] would here be inhibited.

Treatment of ω-chlorodiphenylformazan (III, Z = Cl) with sodium hydrosulphide yields dithizone itself and affords a convenient synthesis of this reagent labelled with radiosulphur.

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Organic Derivatives of Montmorillonite

The supposed analogy between hydrogen-saturated montmorillonite and a weak organic acid has encouraged several investigators, notably Berger[1] and Deuel[2–4], to attempt to esterify the montmorillonite acid using standard organo-chemical methods.

In our opinion, the experimental evidence so far presented to establish the course and extent of the esterification reaction is inconclusive. Thus, Berger[1] determined the methoxyl content of the product obtained by treating hydrogen montmorillonite with diazomethane in ether without showing that it was free of methyl alcohol and ether. Some of the experiments of Deuel are open to similar criticism. Deuel[2–4] generally determined the extent of esterification by the decrease in the exchange capacity of montmorillonite. We have found that exchange-capacity measurements made by conventional methods on previously dried hydrogen montmorillonite are unreliable owing to a decreased rate of exchange with inorganic cations. Our studies have led us to conclude that in all cases hydrogen montmorillonite was his final product, and therefore the reported decreases

in exchange capacity may have been greatly overestimated.

We have examined a number of derivatives prepared by Deuel[2]. The esters examined were the methyl, ethyl and propyl esters prepared from montmorillonite chloride and the corresponding alcohol, the monoglycol ester prepared from hydrogen montmorillonite and ethylene oxide, and a mustard gas ester prepared from sodium montmorillonite. Montmorillonite chloride was prepared by the action of thionyl chloride on dry montmorillonite.

The analysis of these samples for total carbon did not agree with the results of Deuel[2] for the degree of esterification. Our results for the exchange capacity were much higher than those quoted by Deuel[2] and varied according to the method used. All the samples showed lattice expansion with glycerol and some with water, giving (00*l*) spacings identical with hydrogen montmorillonite. We concluded that this behaviour was not compatible with the alleged hydrophobic character of the esters, and was more in keeping with that of hydrogen montmorillonite with sorbed organic contaminants.

Deuel suggested in a private communication that our results might be due to hydrolysis of the esters, and recommended that we repeat the work with freshly prepared samples and extend it to the stable organosilanes of montmorillonite.

To study a fresh sample, we prepared the monopropylene glycol ester from hydrogen montmorillonite and propylene oxide and determined its exchange capacity. This was the same as the original hydrogen montmorillonite. Both samples had lower exchange capacities, 52 m.equiv. / 100 gm., than sodium montmorillonite, 90 m.equiv./100 gm.

Prof. Deuel sent us two samples of the organosilanes of montmorillonite, namely, the ethyl and phenyl derivatives. These had been prepared from montmorillonite chloride by the Grignard and Friedel–Crafts reactions respectively[4]. The ethyl derivative was indistinguishable from hydrogen montmorillonite in having a similar exchange capacity to triethylammonium ions and expanding with water and glycerol. The phenyl derivative, which had a low exchange capacity, did not expand with water or glycerol and contained sulphur probably organically combined. We are of the opinion that this complex consists of montmorillonite with sorbed thiophene or its degradation products, since we have only been able to repeat the preparation using benzene contaminated with thiophene.

A more detailed account of our results will appear shortly.

We thank Prof. Deuel for samples of his preparations. One of us (R. G.-K.) wishes to acknowledge a research grant from the Agricultural Research Council, and another (K. N.) took part in this work during the tenure of a Commonwealth Scientific and Industrial Research Organization (Australia) studentship.

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Irreversible Inactivation of the Cationic Groups of Collagen by High-Molecular Acids

In the irreversible fixation of large molecules by collagen of bovine skin, the steric conditions of the protein chains and the location of the reactive groups of the agent would be expected to be prominent. Some findings obtained on investigating such systems appear to be of sufficient interest to protein chemistry generally to merit their publication.

The first example concerns the irreversible binding of high-molecular ligno-sulphonic acid by collagen. High-molecular fractions of the acid were prepared from calcium ligno-sulphonate by the conventional method[1]. In series I, a high-molecular fraction of ligno-sulphonic acid, the molecular size of which has recently been studied by Ivarsson[2], was used. It contained 7·28 per cent sulphur and 13·1 per cent methoxy groups. Its average equivalent weight was 450 (by titration). The average molecular weight was 8,400[2]. The molecule of ligno-sulphonic acid should then contain an average number of 20 sulpho-acid groups. In series II a ligno-sulphonic acid fraction prepared by precipitation of the highest molecular fraction of the dialysed acid by means of *bis*dimethylaminodiphenylmethane[3] was employed (6·5 per cent sulphur and 10·3 per cent methoxy-groups). Its average equivalent weight was 500 (by titration). The molecular size is not known. However, it is expected to be greater than that of series I.

Standard hide powder (Lyon) was used as substrate; it contained 0·38 per cent sulphur on the weight of protein (Grote–Krekeler) and less than 0·1 per cent ash. Its acid-binding capacity was 0·92 mgm. equivalent hydrochloric acid per gm. collagen. Portions of hide powder equal to 2·00 gm. collagen were shaken for 48 hr. with 50·0 ml. of 0·1 *N* ligno-sulphonic acid. The treated hide powder was freed from sorbed substances by washing. The residual solution and the washings were collected and made up to 500 ml. The amount of ligno-sulphonic acid irreversibly combined with collagen was obtained indirectly as the difference between the amount of acid used and that in the residue. In the dried ligno-sulphonic acid–hide powder, the contents of collagen (N × 5·56) and sulphur were determined, correcting for the sulphur-content of collagen. The number of free basic groups of ligno-sulphonic acid–collagen compound was determined by the amount of hydrochloric acid removed by 0·5 gm. of the ligno-sulphonic acid–collagen by 24 hr. interaction with 10·0 ml. solution of 0·1 *N* hydrochloric acid[4].

The results are summarized in the accompanying table (p. 758).

The average equivalent weight of the ligno-sulphonic acid used in series I is 430 and in series II 500; the last-mentioned figure is that of the original acid. Apparently the experimental conditions have permitted the maximum fixation of ligno-sulphonic acid by collagen; for the stoichiometric equivalent of the acid is fixed by the protein and the ligno-sulphonic acid–collagen compounds are inert towards hydrochloric acid, or nearly so.

Evidently the large ligno-sulphonic acid molecules, which contain about twenty anionic centres in the molecule, combine stoichiometrically with the protein and inactivate its basic groups completely. In doing so, all twenty sulphonic acid groups should

Series	Final *p*H	Ligno-sulphonic acid fixed by 1 gm. collagen (mgm. equiv.)	Analysis of ligno-sulphonic acid–hide powder				
			Collagen (%)	Total sulphur (%)	Lignin sulphur, on collagen basis (%)	Fixed ligno-sulphonic acid, on collagen basis (%)	Free basic groups of ligno-sulphonic acid–collagen per gm. collagen (mgm. equiv.)
I	1·5	1·00	69·9	2·50	3·19	43·1	0·00
II	1·5	0·96	66·8	2·53	3·40	49·7	0·03

find their oppositely charged partners of collagen, which will mean that this rather large molecule penetrates into the interior of the collagen fibrils, reaching and reacting with the individual chains of the protein. No steric hindrance is shown in this reaction.

In the second case, in which the effect of the steric factor is indicated, the interaction of polymetaphosphoric acid and collagen will be briefly discussed. 0·1 *N* polymetaphosphoric acid was prepared by passing a solution of sodium polymetaphosphate (Graham's salt) through 'Amberlite IR 120' charged with hydrogen ions. The average molecular weight of the phosphate was 7,600, that is, 75 phosphate groups were present in the molecule (determined by the end-group method of Samuelson[5]). In view of the instability of polymetaphosphoric acid, the acid resulting from the ion exchange was used immediately and the time of interaction with hide powder limited to shaking for 2 hr. (2 gm. collagen and 50 ml. 0·1 *N* polyacid). After freeing the treated hide powder from the solution by suction filtering, followed by a quick washing, it was once more shaken in a 50-ml. portion of freshly prepared solution of the polyacid for 2 hr. It was finally washed free from reversibly held polyacid. End-group determination of the average molecular weight of the ion-exchanged polyacid after 2 hr. showed values of the order 3,500–4,000, calculated as the sodium salt[6]. Hence, it is likely that the main part of the polymetaphosphoric acid fixed by collagen contains 35 to 40 anionic groups in the molecule. In the indirect determination of the amount of polymetaphosphoric acid fixed by collagen, the value of 1·36 mgm. equivalent acid per gm. collagen was recorded. The analysis of the phosphated collagen for phosphorus and protein showed 1·40 mgm. equivalent combined phosphorus per gm. collagen. The amount of cationic protein groups not reacting with the polyacid cannot be evaluated by treating the phosphated collagen with hydrochloric acid, on account of hydrolysis and splitting of the fixed polymetaphosphate chains by hydrogen ions, complicated by a partial displacement of fixed phosphate. However, it is probable that the maximum inactivation of basic protein groups is attained in the present instance. It has been found that the uptake of polymetaphosphoric acid tends to increase with the molecular weight of the polyacid.

These observations show that, at the most, only two-thirds of the available phosphate groups of the molecule of polymetaphosphoric acid can find their positively charged partners in the collagen lattice, probably due to unfavourable steric conditions.

In view of our meagre knowledge of the chemistry of the components of the systems investigated, there is little use theorizing. However, the stoichiometric interaction of twenty ionic groups of the large sulpho-acid molecule with all the ionic sites of a fibrous protein is remarkable. Evidence at hand suggests that the most likely form of the ligno-sulphonic acid molecule is a prolate spheroid[7]; the spherical and linear forms are excluded[7,8]. The high rate of diffusion of such a large molecule as that of ligno-sulphonic acid into the skin net-work and its ability to penetrate into the fibrils may possibly be due to the regular interspacing of numerous ionic centres in the molecule. The penetration may then be facilitated by means of the attraction of the positively charged protein groups to the negatively charged sites on the diffusing molecule—a mechanism similar to that of a zip-fastener. The large ligno-sulphonic acid molecule can probably adapt itself to the steric conditions of the protein lattice.

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Formation of Amino-Acids in Hydrolysis of Adenine

The new sensitive methods of recognizing amino-acids (for example, paper chromatography) make it necessary to re-examine the degradation products appearing after hydrolysis of non-protein substances containing nitrogen in biological material under investigation. It is, for example, important to know whether significant amounts of amino-acids can occur in hydrolysates of purines and pyrimidines, and obscure the results of amino-acid analysis of nucleoproteins.

According to Kossel[1], adenine can be boiled in hydrochloric acid without being affected, but he also states: "Bei einer 100° übersteigenden Temperatur erfolgt eine völlige Zersetzung unter Bildung von Kohlensäure, und Ammoniak". Krüger[2] continued these experiments and found that adenine is completely split up after 12–14 hr. in hydrochloric acid ($D = 1{\cdot}19$) heated to 180°–200°. A complete splitting at 135° is said to take place "beim mehrtägigem Erwärmen". The degradation products were found to be ammonia, carbon dioxide, glycine and formic acid, which decomposes into water and carbon monoxide.

The production of formic acid was studied by Stevens[3], who separately heated adenine, guanine, sodium thymonucleate and some of the pyrimidines with steam in 30 per cent sulphuric acid. After 24 hr., 25–27 per cent of the adenine had produced formic acid. Only 1 per cent of the guanine was broken up, and the pyrimidines remained unaffected.

The sodium-nucleate gave formic acid in proportion to its content of adenine.

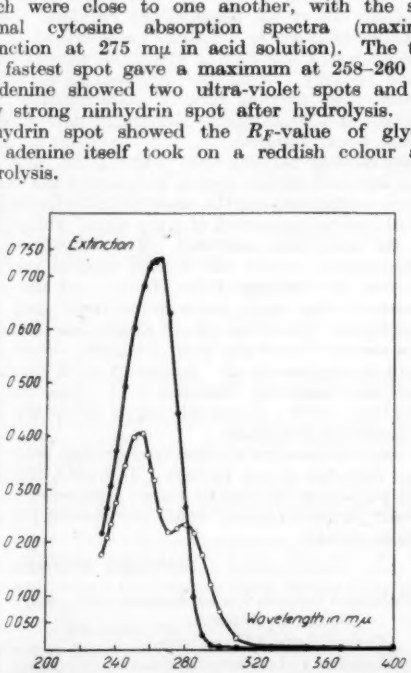
In a recent paper, Smith and Markham[4] point out the risk involved in hydrolysis of ribonucleic acids with mineral acids.

In this laboratory commercial adenine, guanine, cytosine and thymine were investigated. These substances were heated for 24 hr. in 40 per cent hydrochloric acid in sealed tubes at 105°–110°. The hydrochloric acid was evaporated off on a water bath (about 2 hr.). Two commercial adenine preparations were investigated, one from B. L. Lembke (New York), and the other from Hoffmann-LaRoche (Basle). The guanine was also from Lembke, the cytosine from Dougherty Chemicals (Richmond Hill, N.Y.) and the thymine from Schwarz Laboratories (New York).

The four substances were run separately on paper with butanol/10 per cent acetic acid, and the paper strips were sprayed with ninhydrin after having been checked under a 'Mineralight' lamp for the purine and pyrimidine spots. All substances gave normal absorption spectra before hydrolysis, and, with the exception of thymine, only one spot on the paper chromatogram in ultra-violet light. The thymine preparation showed a second very weak spot originating from a very small amount of impurity. All four substances were free from amino-acids before hydrolysis.

Thymine and cytosine, hydrolysed as described above, gave no reaction whatsoever with ninhydrin, whereas guanine showed a trace of amino-acid, which, however, probably introduces no important error in normal analysis. Guanine gave only one spot in ultra-violet light. Thymine showed two spots, the slower of which was very weak and probably due to the impurity. Cytosine gave three spots, two of which were close to one another, with the same normal cytosine absorption spectra (maximum extinction at 275 mμ in acid solution). The third and fastest spot gave a maximum at 258–260 mμ.

Adenine showed two ultra-violet spots and one very strong ninhydrin spot after hydrolysis. The ninhydrin spot showed the R_F-value of glycine. The adenine itself took on a reddish colour after hydrolysis.



Absorption of the two components in an adenine hydrolysate

In additional experiments on the hydrolysis of adenine, both the strength of the acid and the time of boiling were varied. The mildest treatment was to dip a sealed tube of adenine dissolved in 0·9 *M* hydrochloric acid in boiling water for two hours and then to evaporate on a water bath for 90 min. The ultra-violet absorption of the solution as measured in the Beckman spectrophotometer showed a small but definite decrease after hydrolysis. The dried hydrolysed material was redissolved in alcohol and put on paper. The two spots observed were cut out and left in 4 ml. of 1 *M* hydrochloric acid overnight. The extracts were then measured in the Beckman spectrophotometer against blanks made from a strip of the same paper. Typical curves are reproduced herewith.

The single-peaked curve agrees with the absorption of adenine. The adenine spot moved fastest with an R_F-value of about 0·50, and the spot giving the double-peaked curve moved with an R_F-value of about 0·37, or slightly faster than glycine (R_F = 0·34, determined from parallel runs with commercial glycine). If the paper was sprayed with ninhydrin, an easily detectable glycine spot was seen even after this weak hydrolysis. The destructive effects, for example, oxidation besides hydrolysis, which may take place during the evaporation, must also be taken into account when these results are discussed.

Cytosine, hydrolysed in a sealed tube as above and analysed by paper chromatography, shows three spots under the 'Mineralight' lamp. The third and fastest is just detectable.

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Use of Glass Fibre Material in Soil Mycology

The life of fungi in the soil has so far been studied mainly by indirect methods, such as isolation and pathogenicity experiments. Direct methods have been fewer and have included variations of the Rossi–Cholodny slide technique and examination of the soil itself[1]. Investigation of the fate of fungi added to non-sterile soil has been limited by the difficulty of subsequent location of the fungi, except where the original inoculum produced or consisted of macroscopic structures such as sclerotia[2]. As Garrett[3] points out, the introduction into the soil of a fungus growing on a nutrient medium upsets the microbiological equilibrium; results obtained therefore are not a true reflexion of conditions in natural soil. Many fungi, including *Phytophthora*, can be cultured on sterilized soil; but this gives little indication of their ability to survive and spread under natural conditions[4]. In continuing my study of species of *Phytophthora*[5], I have evolved the following technique for use in soil investigations.

Appropriate lengths of glass fibre tape 1 in. wide and 0·003 in. thick and glass fibre threads 0·003 in. thick (made by Fibreglass, Ltd., St. Helens, Lancs) were placed on oatmeal agar plates which were then inoculated with species of *Phytophthora*. After

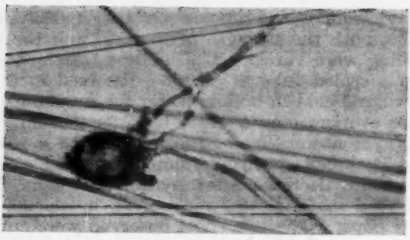

Fig. 1. Oospore of *P. megasperma* after burial in soil for one week. Oospore among glass fibres in Petri solution and germinating by hyphæ. (× 220)

incubation for a month, the fungus hyphæ had become interwoven with the glass fibres and had produced sexual and asexual reproductive structures. The tapes and threads were removed from the cultures without any adhering agar and kept damp while the ends of the tapes were turned back and sewn with glass thread to prevent unravelling. In other experiments agar from the culture plates was included in the loops sewn at the ends of the tapes. The glass material with its inoculum of *Phytophthora* was then buried, either in the upper six inches of non-sterile garden soil out-of-doors or in similar soil in flower-pots in a cold greenhouse. Subsequent location of the tapes and threads was facilitated by hanging them from lengths of wire just below the soil surface. They were extracted after periods of time varying from a day to a year. Soil was washed off under a slow stream of water and the material fixed and stained for immediate examination or left in water or Petri solution for sporangial production. If detailed observation or photography of a particular fungal structure was required, the relevant portion of glass was cut away and the constituent fibres teased apart. After immersion in liquid medium, small portions of the tapes or agar were inserted in surface-sterilized apples in order to recover the *Phytophthora* species.

After burial in the soil for only a week, oospores of *P. cactorum* and *P. megasperma* on glass threads were seen to germinate in Petri solution with the production of hyphæ and rarely sporangia (Fig. 1). Oospores of the same two fungi were still present on tapes and in agar after burial for a year; they germinated to produce sporangia (Fig. 2) and pure cultures were obtained. The shells of oospores which presumably had germinated during burial were also observed in the agar. No evidence of the presence of *Phytophthora* was obtained from controls of glass material and agar utilized throughout all experiments. This investigation is not yet complete; but the method is reported here as it may be of use to other mycologists working with fungi in soil.

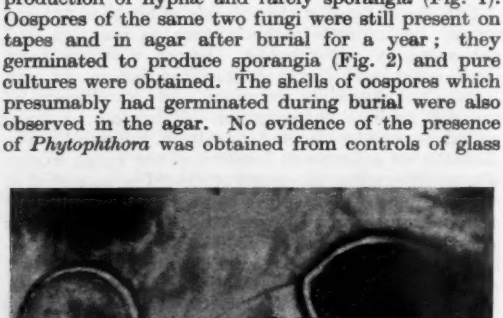

Fig. 2. Oospore of *P. cactorum* after burial in soil for one year. Oospore in agar in Petri solution and germinating by a hypha and a sporangium. Sporangium (on right) slightly plasmolysed. (× 660)

I am grateful to Mr. Ernest Ashby for taking the photographs.

Betty J. Legge

Department of Cryptogamic Botany,
University of Manchester.
Mar. 11.

[1] Walkup, J. H., *Trans. Brit. Mycol. Soc.*, **34**, 376 (1951).
[2] Garrett, S. D., *Trans. Brit. Mycol. Soc.*, **32**, 217 (1949).
[3] Garrett, S. D., *Biol. Rev.*, **9**, 351 (1934).
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Breeding Behaviour of the Emperor Penguin

Man has very seldom had the opportunity of observing the breeding behaviour of *Aptenodytes forsteri*, the emperor penguin. Few rookeries have so far been discovered; all are around the coast of the Antarctic, and all are difficult of access from expedition bases, particularly during the winter months when breeding occurs.

The first rookery, discovered in 1901 at Cape Crozier, was visited on a number of occasions by members of Scott's two antarctic expeditions. Observation during the incubation period was limited to a few hours. The report by Dr. Edward Wilson (1907) is the most comprehensive account so far available of the natural history of these birds.

In 1948 a fourth rookery was discovered fifty miles from one of the bases of the Falkland Islands Dependencies Survey. During the following winter (June–August) I was able to spend ten weeks observing the rookery during the egg-laying, incubating and early post-hatching periods. As a result of these observations a considerable amount of new information has been obtained.

Observations indicate that immediately after the egg is laid, the female moves out across the sea ice to open water, leaving the male to hold the egg for the full incubating period of sixty days. During this time the male does not feed. Towards the end of the incubation period the female returns ready to take over the feeding of the chicks, and the males disperse to the open water after their long fast. Characteristic behaviour at all stages was observed, and a series of embryos was obtained. Work is at present in progress on the interpretation of the results under the following headings: (1) breeding and incubating habits; (2) morphology; (3) embryology, and growth of the chick.

It was not possible to observe courtship behaviour, or the dispersal of the rookery. It would, therefore, be of particular interest if future observers on any emperor penguin rookery could pay special attention to these points.

Bernard Stonehouse

Falkland Islands Dependencies
Scientific Bureau,
Queen Anne's Chambers,
Broadway, London, S.W.1.
Feb. 5.

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, May 5

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS (at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2), at 5 p.m.—Annual General Meeting; Dr. J. E. Flood, Mr. L. R. F. Harris and Mr. A. D. V. Ridlington: "A General Introduction to Communication Theory".

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 5 p.m.—Dr. W. B. Fisher: "Some Problems of Libyan Geography".

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE (in the Lecture Theatre, Science Museum, Exhibition Road, London, S.W.7), at 5.30 p.m.—Sixth Annual General Meeting; Dr. F. Sherwood Taylor: Presidential Address.

SOCIETY OF ENGINEERS (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. B. F. P. Babcock: "From Sink to Sea".

UNIVERSITY OF LONDON (in the Eugenics Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Mrs. C. Payne-Gaposchkin (Harvard): "Variable Stars and Galactic Structure".* (Further Lectures on May 7 and 8.)

UNIVERSITY OF LONDON (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.30 p.m.—Dr. A. Lwoff (Paris): "Development at the Cellular Level. 1, Self-reproducing Particle in the Development of Ciliates".* (Further Lectures on May 6 and 8.)

SOCIETY OF CHEMICAL INDUSTRY LONDON SECTION (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Dr. E. F. G. Herington: "Laboratory Fractionation".

Tuesday, May 6

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENTS SECTION (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Mr. R. S. J. Spilsbury: "The Electricity Division of the National Physical Laboratory".

ROYAL ANTHROPOLOGICAL INSTITUTE (at 21 Bedford Square, London, W.C.1), at 5.30 p.m.—Dr. Ruth Landes: "A Preliminary Statement of a Survey of Negro–White Relationships in Britain".

SOCIETY OF CHEMICAL INDUSTRY, CHEMICAL ENGINEERING GROUP (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Messrs. C. M. Nicholls and A. S. White: "Chemical Engineering and Atomic Energy".

INSTITUTION OF MECHANICAL ENGINEERS (at Storey's Gate, St. James's Park, London, S.W.1), at 6.30 p.m.—Mr. R. J. Sherwood: "Industrial Health Engineering".

MANCHESTER GEOGRAPHICAL SOCIETY (at the Geographical Hall, 16 St. Mary's Parsonage, Manchester), at 6.30 p.m.—Prof. W. A. Lewis: "Economic Development of Under-Developed Countries".

Wednesday, May 7

ROYAL MICROSCOPICAL SOCIETY, BIOLOGICAL SECTION (at Tavistock House South, Tavistock Square, London, W.C.1), at 6 p.m.—Prof. C. M. Pomerat: "Rhythmic Pulsatile Activity in Cells from the Central Nervous System".

UNIVERSITY OF LONDON (in the Beveridge Hall, Senate House, London, W.C.1), at 6 p.m.—Dr. A. L. Goodhart: "The Purpose of a University" (Birkbeck College Haldane Memorial Lecture).*

BRITISH INSTITUTION OF RADIO ENGINEERS, LONDON SECTION (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 6.30 p.m.—Dr. W. Saraga, Mr. D. T. Hadley and Mr. F. Moss: "An Aerial Analogue Computer—an 'Instantaneous' Radiation Pattern Tracer and 'Design Apparatus' for Directional Arrays".

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 7 p.m.—Scientific Papers.

Thursday, May 8

PHYSICAL SOCIETY, OPTICAL GROUP (at the Imperial College of Science and Technology, Imperial Institute Road, London, S.W.7), at 2.30 p.m.—Dr. E. H. Linfoot and Dr. E. Wolf: "Diffraction Images in Refracting Telescopes"; Mr. C. G. Wynne: "The Aberrations of Space Imagery".

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Dr. G. B. Harrison: "The Research Laboratories of Ilford, Limited".

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. J. G. Hawkes: Colour Films of Mexico and South America taken during Potato collecting and research expeditions, 1939 and 1948–51.

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 5 p.m.—Sir Cyril Burt: "Contributions of Psychology to Social Problems" (Hobhouse Memorial Lecture).*

TELEVISION SOCIETY (at the Cinematograph Exhibitors' Association, 168 Shaftesbury Avenue, London, W.C.2), at 7 p.m.—Mr. Baldwin Banks and Dr. K. Frank: "Image Orthicon Camera Tubes".

CHEMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 7.30 p.m.—Scientific Papers.

Thursday, May 8—Saturday, May 10

SOCIETY OF CHEMICAL INDUSTRY, FOOD AND AGRICULTURE GROUPS (joint meeting with the SCOTTISH SECTIONS of the SOCIETY, in the Edinburgh Suite of the Assembly Rooms, George Street, Edinburgh).—Conference on "The Quality of Cereals and their Industrial Uses".

Friday, May 9

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Scientific Papers.

SOCIETY OF CHEMICAL INDUSTRY, PLASTICS AND POLYMER GROUP (in King Charles's Suite, 4 Whitehall Court, London, S.W.1), at 5 p.m.—Twentieth Annual General Meeting; at 5.30 p.m.—Dr. R. F. Boyer: "A New Molecular Weight Distribution Technique".

SOCIETY OF DYERS AND COLOURISTS (in Room 104, College of Technology, The Newarke, Leicester), at 6.45 p.m.—Dr. F. C. Wood: "Non-Felting Wool and Wool Mixtures" (Ninth Mercer Lecture).*

INSTITUTE OF ECONOMIC ENGINEERING (at the Engineers' Club, Albert Square, Manchester), at 7 p.m.—Mr. W. J. Worsdale: "Production Control as a Management Tool".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Mr. P. Evans: "Mountains and Gravity".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

PRINCIPAL OF THE MUNICIPAL TECHNICAL COLLEGE—The Director of Education, Education Office, St. Helens (May 9).

ASSISTANT (Grade B) IN CHEMISTRY at the Glamorgan Technical College, Treforest—The Director of Education, County Hall, Cardiff (May 10).

ASSISTANT LECTURER IN THE BOTANY DEPARTMENT—The Secretary, Edinburgh and East of Scotland College of Agriculture, 13 George Square, Edinburgh 8 (May 10).

HEAD OF THE ELECTRICAL ENGINEERING DEPARTMENT—The Clerk to the Governors, Woolwich Polytechnic, Woolwich, London, S.E.18 (May 10).

LECTURER IN THE DEPARTMENT OF INORGANIC AND PHYSICAL CHEMISTRY—The Registrar, The University, Liverpool (May 10).

RESEARCH ASSISTANT for chemical analytical work in connexion with the effect on the field bean of treatments with certain rare elements in relation to growth and disease resistance—The Secretary, School of Agriculture, Downing Street, Cambridge (May 10).

SCIENTIFIC OFFICERS (2) IN THE POLLUTION AND FISHERIES DEPARTMENT—The Clerk of the Trent River Board, 206 Derby Road, Nottingham (May 10).

SENIOR LECTURER for Part II of the DEGREE OF B.Sc. ENGINEERING of the University of London, a LECTURER IN METALLURGY for the DEGREE of B.Sc. ENGINEERING, a LECTURER preferably with a knowledge of CIVIL ENGINEERING MATERIALS and SOIL MECHANICS, a LECTURER and ASSISTANT (Grade B) IN MECHANICAL ENGINEERING subjects—The Clerk to the Governors, Woolwich Polytechnic, Woolwich, London, S.E.18 (May 10).

LECTURER IN PHYSIOLOGY at the University of Queensland—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (May 12).

RESEARCH ASSISTANT to undertake a mathematical analysis of the spread of a crack in a ductile material—The Registrar, The University, Edgbaston, Birmingham (May 12).

RESEARCH OFFICER (honours graduate in science—chemistry, biochemistry or biology—preferably with some knowledge of bacteriology and biochemistry and research experience) to carry out investigations concerning the spoilage and preservation of fish, at the Torry Research Station, Aberdeen—The Secretary, White Fish Authority, Conyngham Hall, Knaresborough, Yorks (May 12).

RESEARCH STUDENTSHIPS IN THE DEPARTMENTS OF CHEMISTRY, GEOGRAPHY and ZOOLOGY—The Registrar, University College, Hull (May 12).

RESEARCH ASSISTANTS IN THE DEPARTMENT OF PHYSICS AND MATHEMATICS, for a range of work on electronics, with particular reference to the performance and characteristics of thermionic valves and associated equipment—The Registrar, College of Technology, Suffolk Street, Birmingham 1 (May 13).

CHEMISTS IN THE DEPARTMENT OF RESEARCH AND SPECIALIST SERVICES, Southern Rhodesia—The Secretary, Southern Rhodesia Government, 429 Strand, London, W.C.2 (May 14).

LECTURER IN ENGINEERING MATHEMATICS (including Practical Applied Mechanics)—The Secretary, Queen's University, Belfast (May 15).

ROOF CONTROL ENGINEER (with a first-class Colliery Manager's Certificate and, preferably, a degree in mining) in the Production Department at London headquarters, for the investigation and dissemination of technical information on progress made in the field of roof control, the study of systems of strata control generally, and all systems of face and roadway support—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/461 (May 15).

RESEARCH CHEMIST (graduate of a recognized University who has specialized in chemistry, with at least three years experience of research on marine products, marine oils, or fish processing) IN THE DEPARTMENT OF FISHERIES, Ceylon—The High Commissioner for Ceylon in the United Kingdom, 13 Hyde Park Gardens, London, W.2 (May 15).

HEAD OF THE BUILDING AND CIVIL ENGINEERING DEPARTMENT—The Principal, Royal Technical College, Salford 5 (May 16).

ASSISTANT PSYCHOLOGIST (honours degree, or equivalent qualification, in psychology essential)—The Dean, Institute of Neurology, National Hospital, Queen Square, London, W.C.1 (May 21).

SENIOR PRINCIPAL RESEARCH OFFICER (with a University honours degree in science or agricultural science, wide research experience in plant biochemistry or plant physiology, together with ability to lead and integrate the efforts of a team of research workers) IN THE DIVISION OF PLANT INDUSTRY, Canberra, to organize and lead all chemical and physiological research work within the Division—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting No. 3832 (May 24).

CIVIL HYDROGRAPHIC OFFICERS (with a good honours degree in either geography, mathematics, physics, engineering, geology, or a kindred subject) in the Hydrographic Department, Admiralty—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S.217/52 (May 29).

LECTURER and ASSISTANT LECTURERS IN CIVIL ENGINEERING—The Secretary, Queen's University, Belfast (May 30).

ASSISTANT LECTURER IN PHYSIOLOGY—The Registrar, University College, Cathays Park, Cardiff (May 31).

PHYSICIST and a METALLURGIST (with some years research experience at a recognized centre in either physical metallurgy (Ref. No. 3792) or solid-state physics (Ref. No. 3793), for research and development in the field of semi-conductors (transistors) and to work in close association with circuit engineers in a modern well-equipped laboratory in the Radiophysics Division, Sydney—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (May 31).

PROFESSOR OF SOCIAL ANTHROPOLOGY, and a SENIOR LECTURER IN BOTANY, at Rhodes University, Grahamstown, South Africa—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (May 31).

SENIOR LECTURER IN MEDICAL CHEMISTRY at the University of Sydney—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (May 31).

PRINCIPAL RESEARCH OFFICER or SENIOR RESEARCH OFFICER, Coal Research Section of the Commonwealth Scientific and Industrial Research Organization, Sydney, to conduct fundamental investigations on the physical properties of Australian coals and of the cokes made therefrom, and to be responsible for the work of the Section dealing with investigations into the hardness, friability, grindability of coal, etc.—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting No. 3834 (June 7).

ASSISTANT LECTURER IN CLINICAL PSYCHOLOGY in the Department of Psychiatry—The Registrar, The University, Manchester 13 (June 14).

LECTURER IN BIOCHEMISTRY AND NUTRITION at the Home Science School, University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (June 15).

AGRICULTURAL ECONOMIST (with a University degree in agricultural economics or equivalent qualification), Northern Rhodesia—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting Ref. 27306/13.

ASSISTANT EXPERIMENTAL OFFICERS—The Secretary, Grassland Research Station, Drayton Manor, Stratford-on-Avon.

ASSISTANT LECTURER IN APPLIED MATHEMATICS—The Registrar, The University, Nottingham.

ASSISTANT LECTURER (Grade B) IN PHARMACEUTICS—The Registrar, College of Technology, Unity Street, Bristol 1.

CHEMISTS at the Ministry of Supply Radiochemical Centre, Amersham, to be concerned with the synthesis of compounds labelled with radioactive isotopes, particularly Carbon-14, and with allied research problems—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting F.255/52A.

DEPUTY GOVERNMENT GEOLOGIST in the Sudan—The Sudan Agent in London, Wellington House, Buckingham Gate, London, S.W.1, endorsed 'Deputy Government Geologist 1810'.

ENTOMOLOGIST (with an honours degree in zoology with experience in entomological work) IN THE DEPARTMENT OF AGRICULTURE, British Guiana—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting Ref. 27059/38.

JOSEPH LUCAS FELLOWSHIP IN ELECTROMETALLURGY—The Registrar, The University, Edgbaston, Birmingham 15.

PHYSICISTS or ELECTRICAL ENGINEERS for investigations on electrical breakdown in dielectrics—The Director, Electrical Research Association Laboratory, 5 Wadsworth Road, Greenford, Middx.

SENIOR INVESTIGATOR (with a degree in metallurgy, physics or engineering) for a programme of research on the joining of metals, and SENIOR INVESTIGATORS and RESEARCH ASSISTANTS (with degrees in metallurgy, physics or engineering, or equivalent qualifications) for research on the production and properties of clad metals—The Registrar, The University, Edgbaston, Birmingham 15.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

University Grants Committee. University Development: Interim Report on the Years 1947 to 1951. (Cmd. 8473.) Pp. 28. (London: H.M. Stationery Office, 1952.) 1*s*. net. [282

Foreign Periodicals and Serials on Pure and Applied Science and Economics received in the Science and Technology Library through the Organisation for European Economic Co-operation. Second edition. Pp. ii+10. (Sheffield: Central Library, 1952.) [282

Annals of Physical Medicine: the Official Organ of the British Association of Physical Medicine. (Quarterly.) Vol. 1, No. 1, January. Pp. 36. (London: Headley Brothers, Ltd., 1952.) 6*s*. net; annual subscription, 21*s*. net. [43

Macaulay Institute for Soil Research. Collected Papers, Vol. 3, 1948–1951. Edited by Dr. D. N. McArthur. 52 papers. (Aberdeen: Macaulay Institute for Soil Research, 1951.) [43

Handbook of Scientific Instruments and Apparatus 1952, as shown at the 36th Physical Society Exhibition to be held at Imperial College, South Kensington, London, S.W.7, from Thursday, 3rd April to Tuesday, 8th April. Pp. xi+244+A76. (London: Physical Society, 1952.) [53

University of Cambridge. Report of the Observatories Syndicate for the Year ending 1951 September 30. Pp. 4. (Cambridge: The University, 1952.) [53

Ministry of Agriculture and Fisheries. Bulletin No. 76: Culinary and Medicinal Herbs. Second edition. Pp. iv+46+4 plates. (London: H.M. Stationery Office, 1951.) 1*s*. 9*d*. net. [63

Transactions of the Royal Society of Edinburgh. Vol. 62, Part 1, No. 8: Structure and Biology of the Larva and Spat of *Venerupis pullastra* (Montagu). By Dr. D. B. Quayle. Pp. 255–297+1 plate. (Edinburgh and London: Oliver and Boyd, Ltd., 1952.) 11*s*. [63

Adult Education in a Changing Society: an Inaugural Lecture delivered at University College, Leicester, 1st May 1951. By Prof. A. J. Allaway. Pp. 29. (Leicester: University College, 1951.) 1*s*. net. [63

Science and Film. (Quarterly.) Vol. 1, No. 1, February. Pp. ii+48. (London: Science and Film, c/o Scientific Film Association, 1952.) Annual subscription, 10*s*. 6*d*. [63

Royal Institute of Chemistry. Lectures, Monographs and Reports 1952, No. 1: Biological Aspects of Proteins in the Light of Recent Chemical Studies. By Dr. R. L. M. Synge. (Second P. F. Frankland Memorial Lecture.) Pp. 16. (London: Royal Institute of Chemistry, 1952.) 4*s*. net. [63

University of Cambridge: Department of Engineering. Report of the Head of the Department for the Year 1950–51. Pp. 9. (Cambridge: University Department of Engineering, 1952.) [63

Department of Scientific and Industrial Research. Report of the Fuel Research Board with the Report of the Director of Fuel Research for the Period 1st April 1949 to 31st December 1950. Pp. vi+60+4 plates. (London: H.M. Stationery Office, 1951.) 2*s*. 6*d*. net. [63

Other Countries

Publications of the Dominion Astrophysical Observatory. Vol. 8, No. 15: Revised Radial Velocities of Seventy-nine B-Type Stars. By J. A. Pearce and R. M. Petrie. Pp. 409–428. (Ottawa: King's Printer, 1951.) [132

United States Department of Commerce: National Bureau of Standards. Circular 507: X-Ray Calibration of Radiation Survey Meters, Pocket Chambers and Dosimeters. By Frank H. Day. Pp. ii+11. (Washington, D.C.: Government Printing Office, 1951.) 15 cents. [142

Smithsonian Institution: United States National Museum. Bulletin 201: A Review of the Mysidacea of the United States National Museum. By Walter M. Tattersall. Pp. x+292. (Washington, D.C.: Government Printing Office, 1951.) 1 dollar. [142

Annual Report of the Board of Regents of the Smithsonian Institution, showing the Operations, Expenditures and Condition of the Institution for the Year ended June 30, 1950. (Publication 4025.) Pp. ix+522+84 plates. (Washington, D.C.: Government Printing Office, 1951.) 3 dollars. [142

Kungl. Svenska Vetenskapsakadamiens Handlingar. Band 2, No. 5: Meridian Observations of Faint AG Stars. By Anders Reiz. Pp. 150. (Stockholm: Almquist and Wiksell; London: H. K. Lewis and Co., Ltd., 1951.) 16 kr. [142

Department of Commerce and Industries: Fisheries and Marine Biological Survey Division. Fisheries Bulletin No. 3: The Fisheries Research Ship *Africana II*. By Dr. J. M. Marchand, R. L. V. Shannon and A. Clark. Pp. 47. (Sea Point, S. Africa: Fisheries and Marine Biological Division, 1951.) [63

Bulletin des Laboratoires de Géologie, Minéralogie, Géophysique et du Musée Géologique de l'Université de Lausanne. Bulletin No. 98: Gravimètre et structures géologiques. Par N. Oulianoff. Pp. 13. Bulletin No. 99: Marées de la terre ferme à Lausanne. Par Pierre-A. Mercier. Pp. 10. (Lausanne: Laboratoires de Géologie, Minéralogie, Géophysique et du Musée Géologique de l'Université, 1951.) [63

Institut pour l'Encouragement de la Recherche Scientifique dans l'Industrie et l'Agriculture. Comptes rendus de recherches, No. 6: Travaux du Centre de Recherches des hormones végétales (1949–1950). Pp. 134. (Bruxelles: Institut pour l'Encouragement de la Recherche Scientifique dans l'Industrie et l'Agriculture, 1952.) 130 francs. [63

Companhia de Diamantes de Angola. Publicacoes Culturais No. 6: Museu do Dundo. Subsídios para o estudo da biologia na Lunda. Estudos Diversos (Biologia), 1. Pp. 137. Publicacoes Culturais No. 13: Museu do Dundo. Subsídios para o estudo da biologia na Lunda. Estudos Diversos (Biologia), 5. Pp. 97. (Lisboa: Companhia de Diamantes de Angola, 1952.) [63

Meddelelser fra Kommissionen for Danmarks Fiskeri- og Havundersøgelser. Serie Plankton, Bind 5, Nr. 4: The Marine Vegetation of the Isefjord—a Study on Ecology and Production. By E. Steemann Nielsen. Pp. 114. (København: C. A. Reitzels Forlag, 1951.) 18 kr. [63

Basic Research in Agriculture: a Brief History of Research at Amani, 1928–1947. Pp. 24+7 plates. (Nairobi: East African Agriculture and Forestry Research Organisation, n.d.) [63

United States Department of Commerce: National Bureau of Standards. Handbook 49: Recommendations for Waste Disposal of Phosphorus-32 and Iodine-131 for Medical Users. Pp. iv+12. (Washington, D.C.: Government Printing Office, 1951.) 10 cents. [63

Catalogues

The Hanovia 'Chromatolite'. Pp. 2. Hanovia Bactericidal Units. Pp. 4. (Slough and London: Hanovia, Ltd., 1952.)

Antiquariat List for Reviews and Periodicals. Pp. 32. (Milano: Santo Vanasia, 1951.)

Ultrasonic Flaw Detector. Pp. 8. (London: Solus-Schall, Ltd., 1952.)

Catalogue of Books on the Biological Sciences. Pp. 44. (London: H. K. Lewis and Co., Ltd., 1952.)

Everything X-Ray: a Catalogue. Third edition. Pp. 80. (Bushey Village, Herts.: Cuthbert Andrews, 1952.)

Examples from the World's Largest Range of Visual Aid Equipment. Pp. 4. (London: Newton and Co., Ltd., 1952.)

Towers Laboratory News. No. 7. Pp. 181–196. (Widnes: J. W. Towers and Co., Ltd., 1952.)

Example of Use of 'Techne' Viscometer with a Non-Newtonian Liquid. Pp. 8. (Duxford: Techne (Cambridge), Ltd., 1952.)